



AGRICULTURAL RESEARCH INSTITUTE
PUSA

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOLUME 16, 1926

BOARD OF EDITORS

D. F. HEWETT
GEOLOGICAL SURVEY

S. J. MAUGHLY
DEPARTMENT OF TERRESTRIAL MAGNETISM

AGNES CHANG
BUREAU PLANT INDUSTRY

ASSOCIATE EDITORS

L. H. ADAMS
PHILOSOPHICAL SOCIETY

S. A. ROHWER
ENTOMOLOGICAL SOCIETY

E. A. GOLDMAN
BIOLOGICAL SOCIETY

G. W. STOSE
GEOLOGICAL SOCIETY

R. F. GRIGGS
BOTANICAL SOCIETY

J. R. SWANTON
ANTHROPOLOGICAL SOCIETY

E. WICHERS
CHEMICAL SOCIETY

**PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY
BY THE
WASHINGTON ACADEMY OF SCIENCES**

ERRATA

Vol. 16, 1926

Page 88, 14th line from bottom, for "tendon" read "tenon," and, end of line, read "neatly" for "nearly "

Page 88, 12th line from bottom, close ")" after "long" and insert "," after "branch."

Page 91, lines 9 and 10, change to read "It appeared that, after becoming loaded with the molecules, they could not pass."

Page 91, line 22, delete "which "

Page 91, 9th line from bottom, for "could" read "may."

Page 168, line next to last, change "maise" to "maize "

Page 284, line 2, change "Sasinto" to "Jacinto."

Page 433, line 2 of heading, change initial "T." to "L "

Page 469, line 6, for "and Oligocene" read "an Oligocene "

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 16

JANUARY 4, 1926

No. 1

VOLCANOLOGY—*The eruption of Santorini in 1925.*¹ H. S. WASHINGTON, Geophysical Laboratory, Carnegie Institution of Washington

The small island group of Santorini, among the southernmost islands of the Greek Archipelago, is well known through the monumental work of Fouqué, who described the island and its eruptions, especially that of 1806-70. I was able to study the present eruption during the 13th 20th of September last, in company with Prof. K. A. Ktenas, of the University of Athens and his assistant, Dr. P. Kokkonos. At the date of writing, three short notes on the early stages of the eruption, by Prof. Ktenas and others, have appeared.²

Since the explosion that formed the central lagoon in the original prehistoric volcano (Fig. 1), volcanic activity has been almost exclusively confined to a group of small islands in the center of the lagoon, the products of eruptions of different, and all historic, times (Fig. 2). The dates of the chief of these eruptions and the names given to the cones are as follows: Palain Kaimeni,⁴ 46 A. D.; Mikra Kaimeni, 1570 A. B.; Nea Kaimeni, 1707-1711 A. D., and Giorgios Kaimeni, 1866-70. This last was in a feebly fumarolic state when I visited it in 1893. For the present volcano, Prof. Ktenas³ has proposed the name Fouqué Kaimeni, in honor of the eminent French savant, and I gladly adopt his very appropriate name.

After some feeble, apparently preliminary, earthquakes at the end

¹ Received December 3, 1925

² F. Fouqué, *Santorin et ses Eruptions*, Paris, 1870

³ K. A. Ktenas, *C. R. Acad. Sci.* **181**: 376, 1925; Georgalas and Liatsikas, ditto, p. 425, Ktenas, ditto, p. 518

⁴ *Kaimeni* (meaning burnt) is the modern Greek term for the volcanic cones. Palain Kaimeni is not shown in Fig. 2

⁵ Ktenas, *C. R.* **181**: 377, 1925

of July and during the first nine days of August the eruption began on August 11,⁶ and the volcano has been in a continuous state of activity



Fig. 1 Map of the Santorini Group prior to the eruption of 1925

ever since, or at least until October 27 according to a note kindly sent me by Prof. Ktenas. The initial center was submarine, in the strait

⁶ For some details as to the early stages I avail myself of the data in the three papers cited above in addition to information obtained during my visit.

between Mikra Kaimeni and Nea Kaimeni, and apparently about half way between their craters (x in Fig. 2). An islet was formed and lava flows were poured out, which flowed east and north in the narrow

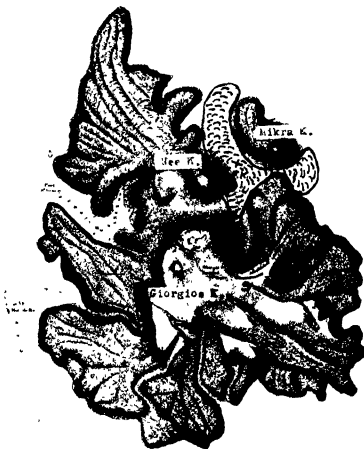


Fig. 2—The central islands of Santorini (from Fouqué, Plate XXIX), showing Fouqué Kaimeni (F. K.) and the two lava flows. September 19, 1925

channel, gradually filling it and rising several meters above the previous water level. When I left September 20 the northern flow had practically ceased moving, but the eastern flow was slowly pushing out into the lagoon, and was still in motion on October 27. A small

lava flow also extended to the south, on the flat land east of the cone of Giorgios.

The lava flows were of the usual Santorini type—loose agglomerate of large and small, angular blocks. An immediate evidence of flow was that these blocks would fall down or tumble over each other from time to time, as the more continuous lava flow, of which they formed the upper part, moved slowly onward. Where the flows entered the lagoon the water was very hot. Dr. Kokkoros measured temperatures up to 69°, and at places near the flows the water was apparently boiling, or almost so. Much steam was given off, and at times there was a rather strong odor of H_2S from the water. Near this part of the shore the lagoon water was colored bright yellow or orange, from the hydrolytic precipitation of iron hydroxide.

The material of the lava flows and of the ejected blocks is a hypersthene andesite that in megascopic and microscopic appearance closely resembles the generality of the Santorini lavas, being dense, black, and highly vitreous. A chemical analysis by Miss Keyes shows that it contains 64.99 per cent of SiO_2 , and that otherwise it is almost identical chemically with other lavas of Santorini, of different dates, that have been analysed.⁷ A description of the petrographical and chemical features must await a later publication, but attention should be called here to the very remarkable and almost unique constancy in physical, modal, and chemical characters that the Santorini lavas exhibit, from the earliest times until the present day.

A good view of Fouqué Kaimeni was to be had with binoculars from the town of Phura, about 2 miles east-northeast. From this point the spectacle at night was magnificent. Near-by views of the dome were to be had from the lagoon, although these were not very satisfactory. Attempts to see and study the eruption from the summit of Nea Kaimeni and the north slope of Giorgios were frustrated by showers of stones, but finally on September 19 good view-points were found along the ridge of the easterly flow of Giorgios Kaimeni, about 500 meters from and about due south of the dome (S in Fig. 2).

From this ridge on September 19, Fouqué Kaimeni was seen to form a low circular dome, estimated by me to be nearly 150 meters in diameter and about 50 meters high.⁸ During our stay its form changed continually, the summit being for a time flat and truncated, again

⁷ Cf. H. S. Washington, C. R. XII Cong Géol Int, 235, 1914

⁸ Ktenas (op cit, 181: 520 1925) estimates the diameter at not over 100-120 meters and the height at about 75 meters. According to him the height of the lava flow in the strait is 20-48 meters above sea level. There would seem to have been some ascensional movement at the east end since my departure.

regularly domal, and again asymmetrical, with an apex at the west side. The dome appeared to be formed of a carapace of solid lava, much cracked and fissured, a brilliant red incandescence being visible at night, but only rarely during the day. The cracks and fissures were constantly altering their position and, although we thought that the dome was a more or less continuous carapace, yet it is possible that it consisted mainly of a mass of loose, piled up lava blocks. No definite crater was visible. The dome rested upon a plateau formed by the earlier lava flows and, to judge from the observations made on September 19 and from Ktenas' map, the center of activity had shifted, from its initial site in the strait, to a point a couple of hundred meters to the south, that is, onto the previously existing shore terrace. A battery of white-vapored fumaroles was in constant activity at the top of the east slope of Nea Kaimeni.

The volcanic activity of Fouqué Kaimeni was continuous but irregularly pulsatory in intensity, and there were at least three kinds of eruption, one being practically uninterrupted, while the other two were intermittent.

(1). From the north end of the Fouqué dome there rose almost continuously a vertical column of white or yellowish vapor, thin at the base and gradually expanding, that attained heights of about 200 meters or more. This gave rise to a loud hissing noise and was unaccompanied by the ejection of stones or ash. Another similar blast of white steam issued, with less force but with intermittent suddenness, from the southeast side of the dome, being projected upward at an angle of rather less than 45° from the horizontal.

(2). The most violent explosions were dominantly of Mercalli's vulcanian type, although there was, at times, some admixture of the strombolian. These spectacular ejections took place from or near the summit of the dome, but apparently not from a fixed point or crater. They occurred at irregular intervals, and consisted of a succession of huge puffs, generally accompanied by a loud and deep roar. Some were practically noiseless. The successive puffs, as at many other volcanoes, formed a thick column, of the usual "cauliflower" type, that attained varied heights, from 500 to 2000 meters and more, gradually thinning out and drifting to leeward at still greater heights. These cauliflower columns were white to dark gray in color, apparently composed very largely of water vapor, highly charged with gray lapilli, sand, and fine ash. There was a scarcely perceptible odor of H_2S at about 500 meters to leeward. The emission of the cauliflower columns was generally accompanied by the violent ejection of many solid blocks of lava, that attained heights of 200-300 meters, and often

much more. The stones were scattered in all directions and to considerable distances, some being found by us near the small harbor of St. George, about 600 meters to the west. It was reported that some had fallen on the shallow former anchorage, the "Banko," about one kilometer to the east, so that this was abandoned by shipping. In daylight most of the ejected stones appeared black, only a few being dull red; but at night they were brilliantly red, forming a magnificent spectacle, as has been said. These blocks varied much in size, from that of one's fist to lengths of 50, 60, or more centimeters. On impact with the ground they broke up, and there was further cracking from the strains set up as the glass cooled. We found no rounded bombs nor other masses evidently ejected in a fluid condition, nor were there any bread crust bombs. We could see no electrical discharges in the columns, either by day or by night.

(3) The third kind of explosion was most unusual—indeed, I can recall no record in the literature of anything exactly like it, although something similar appears to have occurred at Giorgios in April, 1866,⁹ and the eruption of Novarupta, near Katmai in Alaska¹⁰ may have presented some analogous features. The probable cause of the phenomenon will be discussed in a subsequent paper.

As studied with the glass from Phira at night, the foot of the dome of Fouqué Kaimeni was seen to be often partly surrounded by a thin ring of bright red incandescence, evidently an encircling crevice. Occasionally an outer brilliant concentric crevice was visible here and there. These crevices were not evident in the daytime from our viewpoint on September 19, but at intervals there issued from the site of the crevice, at the foot of the dome on the west and southwest sides, a semicircular or quarter-circular series or battery of narrow jets of white or light gray vapor. These jets always exploded simultaneously and formed a crown around the dome. They were approximately equidistant from each other, and not far apart—possibly not more than 10 to 20 meters. They reached altitudes of only about 50 or 100 meters, possibly a trifle more. It seemed that the emission of these series of jets usually preceded the great vulcanian explosions, or were at least coincident with them. I would venture to suggest that the technical term *coronet* be used for this type of volcanic explosion.

At night, from Phira, a few flames were to be seen playing over the dome. These were mostly bluish, but some were yellow or red. They were not visible in the daylight from points near the dome.

⁹ Fouqué, *op. cit.*, p 75

¹⁰ Cf. C. N. Fenner, *Jour Geol* 28: 588. 1920, and *Tech. Papers Nat. Geogr. Soc.*, Katmai Series, 1: 55. 1923.

The inhabitants of Phira and the other towns were somewhat panicky, fearing serious damage to buildings from the volcano or from earthquakes. In our opinion there is scarcely a possibility of danger that the towns on Thera and Therasia will suffer serious damage from the volcano, and probably not from earthquakes, although the vineyards may be damaged from falling ash, especially when the vines begin to burgeon in the spring.

As to the future, it appears to be probable, from analogy with other recent eruptions at Santorini, that the eruption of Fouqué will be of considerable duration—at least one year and probably several years.

ATOMIC PHYSICS.—*Note on the $L_{II}L_{III}$ levels of the atoms Si, P, S, Cl.* SAMUEL K. ALLISON. Geophysical Laboratory, Carnegie Institution of Washington.¹

Many investigators have made measurements of the energy levels of atoms by means of experiments on the photo-electric effect of the radiations given off by these atoms when they are excited by various means. This method is particularly useful in the region between the softest X-rays which can be studied by crystalline diffraction and the shortest wave-lengths in the ultra violet which can be studied with gratings as in the experiments of Millikan.

In some cases it has been possible to compare the energy level values obtained by these photo-electric methods with those obtainable by the ordinary methods of X-ray spectroscopy, either directly, or by application of the combination principle. In the cases in which it has been possible to carry out such comparisons, it has often been found that no convincing agreements could be obtained. For instance, the measurements by Rollefson² of some critical potentials of iron which he ascribes to the L and M series are difficult to reconcile with the recent measurement of the $L\alpha$ and β lines of iron by Siegbahn and Thoraeus.³

It is the purpose of this note to call attention to the fact that recent X-ray measurements by Ray⁴ and Backlin,⁵ together with the older measurements of Lindh^{6,7} make possible a rather rigid comparison between the two experimental methods for obtaining the L_{II} and L_{III} limits of Si, P, S, and Cl. The experiments of these investigators

¹ Received December 1, 1925.

² Rollefson, *Phys Rev* **23**: 35. 1924

³ Siegbahn and Thoraeus, *Arkiv f Mat. Astr Fys.* **18**: No. 24. 1924. See also Siegbahn, *Spectroscopy of X-rays* (English Ed.), p. 238

⁴ Ray, *Phil. Mag.* **60**: 505 1925

⁵ Backlin, *Zs. f. Phys.* **33**: 547. 1925.

⁶ Lindh, *Diss. Lund* (1923)

⁷ Lindh, *Zs f. Phys* **31**: 210 1925

make it clear that the energy levels of these light atoms depend in value on the particular chemical combination in which the atom is involved. From their results it is now possible to calculate the values of the L_{II} , L_{III} levels of these atoms in different chemical combinations.

TABLE I — λ AND ν/R VALUES FOR $K_{\alpha_{1,2}}$ AND $K_{\alpha_{1,3}}$

ELEMENT	COMPOUND	$\lambda(X \text{ U}) K_1$	ν/R	K_{α_1}	$\lambda, \nu/R$	K_{α_2}
14 Si	SiO_2	6707.5	135.85	7100.83	128.224	
	Si	6731.0	135.38	7109.17	128.182	
15 P	P_2O_5	5751.5	158.44	6141.71	148.374	
	P _{red}	5767.4	158.00	6144.43	148.308	
16 S	MSO_4	4987.9	182.70	5358.50	170.061	5360.90 169.984
	S	5008.8	181.93	5300.90	169.984	5363.90 169.889
17 Cl	NaClO_4	4369.4	208.56	(4715)	(193.3)	
	KCl	4382.9	207.92	4718.21	193.139	4721.18 193.017

The result of such a calculation is shown in the tables. The wavelengths have been obtained from the following sources. The K_1 critical absorption wave-lengths of the compounds of P, S, Cl, as well as of the elements themselves, are taken from the dissertation⁶ of Lindh. The value for the K_1 limit of SiO_2 and Si was obtained by Lindh at a later date.⁷ The wave-lengths of the unresolved $K\alpha$ doublet of Si, P in P_2O_5 , and of the $K\alpha_1$ line of Cl in KCl have been taken from the early measurements of Hjalmar.⁸

Recently Backlin⁵ has measured the doublet separation of these lines for Si and P in various compounds but apparently no new absolute measurements of the wave-lengths have been made. The wave-lengths of the $K\alpha$ doublet in sulfur and sulfates (MSO_4) have been taken from the work of Ray.⁴ The wave-length of the $K\alpha_1$ line of Cl in KCl is obtained from $K\alpha$, by the recent measurement of Backlin⁵ of the doublet separation. The wave-lengths of the unresolved $K\alpha$ doublet in SiO_2 and red P have been obtained from the old measurements of Hjalmar on Si and P_2O_5 , by means of the results of Backlin⁵ on the shift of these lines with varying chemical combination. A hypothetical wave-length for the unresolved $K\alpha$ doublet in Cl in NaClO_4 has been inserted on the assumption that a shift of the doublet

⁸ Hjalmar, Phil. Mag. 41: 675. 1921.

of the same order of magnitude as found by Backlin between the lower and highest valences of Si, P, and S occurs. Due to this assumption an error of as much as 1 volt may be introduced into the L_{II} L_{III} levels of Cl in NaClO_4 in Table 3.

TABLE 2 — $\frac{P}{R}$ VALUES OF L LEVELS

ELEMENT	COMPOUND	L_{II}	L_{III}
14 Si	SiO_2	7 63	
	Si	7 20	
15 P	P_2O_5	10 07	
	P_{red}	9 69	
16 S	MSO_4	12 72	12 64
	S	12 04	11 95
17 Cl	NaClO_4	(15 3)	
	KCl	14 90	14 78

TABLE 3 — L LEVELS IN VOLTS

X-RAY SPECTRA				CRITICAL IONIZATION VOLTAGE (HOLWECK)	
Element	Compound	L_{II}	L_{III}	Compound	L_{II} L_{III}
14 Si	SiO ₂	103 4		SiH ₄	98 ± 2
	Si	97 5			
15 P	P ₂ O ₅	136 4		PH ₃	128 ± 2
	P _{red}	131 3			
16 S	MSO ₄	172 3	171 2	H ₂ S	163 ± 1
	S	163 1	161 9		
17 Cl	NaClO ₄	(207)		HCl	203 ± 1
	KCl	201 8	200 2		

Holweck* has made measurements of the L_{II} L_{III} energy levels of the elements Si, P, S, Cl by an ingenious method which differs considerably from the usual photo-electric methods. It is essentially a measurement of the critical ionisation potential of gaseous compounds of these elements by increasing the highest frequency in a beam

* Holweck, Compt. rend. 180: 658 1925.

of X-rays partially absorbed in an ionisation chamber filled with a gaseous compound of the element in question until a sudden increase in the ion current through the chamber shows that a critical frequency has been reached. The skillful technique which enables this method to be applied to very soft X-rays has been described by Holweck. In this work the gaseous compounds SiH_4 , PH_3 , H_2S , and HCl were used. The results for the L_{II} L_{III} limits of Si, P, S, Cl in these compounds are given in Table 3, and are there to be compared with the values obtained from X-ray data for other compounds. Such a comparison has been indicated by Turner.¹⁰ The X-ray data available at that time indicated a discrepancy between the results of Holweck and X-ray predictions, but it will be seen that the present agreement is good.

It is evident from Table 3 that the X-ray data indicate an energy difference in volts between the L_{II} L_{III} levels of these atoms in their highest and lower valencies which is greater than the experimental error which Holweck ascribes to his measurements, and in fact his data agree well with the lower valencies (in Si, P, S with the elements themselves) and disagree definitely with the higher valency values.

The necessity of taking account of the particular chemical compound involved in seeking agreement between data in this region has been emphasized by Siegbahn.¹¹

The agreement between Holweck's measurements on the hydrides and the X-ray values for the free elements in the case of Si, P, S, indicates that the difference between the energy level values of the hydrides and those of the free element is much less than that between those of the free element and its higher "positive" valence compounds with oxygen. Such a result is perhaps not at variance with modern chemical ideas as to the type of linkage in these compounds.

SUMMARY

By application of the combination principle it is possible to calculate the energy values of the L_{II} L_{III} levels in the atoms Si, P, S, Cl in various compounds from recent X-ray data. The resulting values are compared with a determination of these levels in the hydrides of these atoms which was carried out by Holweck by photo-electric methods. The results show that for Si, P, S these levels have very nearly the same energy in the hydrides as in the elementary substance itself, but that in the higher oxides of these elements there is an appreciable difference in this respect between the element and oxide.

¹⁰ Turner, *Phys. Rev.* **26**: 143 1925. (Footnote p. 145.)

¹¹ Siegbahn, *Spectroscopy of X-rays* (English Ed.) p. 241.

BOTANY.—A new circumneutral soil prickly-pear from the Middle Atlantic States. EDGAR T. WHERRY, Bureau of Chemistry.

In the course of studies upon the relation between soil reaction and the distribution of native plants, the prickly-pears of the north-eastern states have received some attention, and evidence has been found that, instead of the single species listed by Britton and Rose,¹ there are actually at least four species represented in this region. One of these appears to have been hitherto unrecognized, and the name *Opuntia calcicola* is here proposed for it, in reference to its frequent growth on calcareous rocks. The differences between them may now be considered.

ACID-SOIL SPECIES

Opuntia compressa.—The most widespread of these prickly-pears is the one long known as *Opuntia vulgaris* Miller, now believed to be more correctly designated as *Opuntia opuntia* (L.) Karsten under codes permitting duplicate binomials, or preferably as *O. compressa* (Salisbury) Macbride. The center of distribution of this species appears to be in the Piedmont of Virginia and adjoining states; it ranges southward to an as yet unknown distance—possibly though not certainly into the Appalachian Plateau province in Alabama—and northward into the Appalachian Valley province of central New York state, the northern Coastal Plain in New Jersey, and the New England Upland in Connecticut and Massachusetts. In all of these regions it grows in rocky or sandy soil which shows a distinctly or often a strongly acid reaction (subacid to mediacid).

This is a prostrate plant with fibrous roots, the joints are orbicular to oblong, averaging 8 to 10 cm. long, rather thick in proportion to their length (except in shaded situations, when they may become much elongated and thinned), and in color (following Ridgway's Color Standards) dull grayish green-yellow, either "jade green" (27" k) or adjacent hues; the leaves are 4 to 5 mm. long, and more or less appressed; slender brown and white-banded spines, about 0.8 mm. thick and 2 cm. long, are occasionally present, one or rarely two to an areole, the numerous glochids are pale dull orange-yellow, near "deep colonial buff" (21" b); the flowers are pure yellow ("lemon yellow", 23), and about 7 cm. in diameter, with 8 or 10 petals; the fruit is obovoid, 3 to 4 cm. long and 1.5 to 2.0 cm. in diameter at the top, more than twice as long as wide only exceptionally in crowded situations, and the seeds are 4 to 5 mm. broad, with a prominent roundish keel.

Opuntia pollardii.—Though usually recorded as limited to the southern states, this species actually extends at least as far north as eastern Maryland and Delaware, if not into New Jersey, growing typically in the subacid to mediacid Coastal Plain sands. It is distinguished from the preceding by having sweet-potato-like thickenings on its roots, thick and stubby joints of

¹ Britton and Rose, *The Cactaceae* 1: 127. 1919.

somewhat more bluish green color (near "cress green", 29''k); more spreading leaves; stouter spines 1.5 to 2 mm. thick and 2 to 4 cm. long; and seeds having an even thicker keel.

CIRCUMNEUTRAL-SOIL SPECIES

Opuntia humifusa.—Though sometimes included under *Opuntia compressa*, the plant from west of the Appalachian Mountains, ranging over the Interior Low Plateau and Central Lowland provinces, from Tennessee to Illinois and Ohio, has several features which distinguish it. It appears to be limited to limestone rock ledges and calcareous gravel. It grows more erect, with larger and relatively thinner joints, usually bearing a glaucous coating, so that their color is near "deep dull yellow green" (31''k), although old joints from which the glaucous coating has disappeared may be similar in hue to those of *O. compressa*; the areoles are fewer and more widely spaced; the leaves are longer and more spreading; 3 to 5 cm. spines are frequently developed, the glochids are strikingly different, being orange-brown in color, near "ferruginous" (9'i) when fresh, becoming "tawny" (13'i) with age; the flowers often have a red center, owing to a triangular blotch of orange-red ("scarlet," 5) at the base of each petal, and the fruit is normally longer in proportion to its width.

Opuntia calcicola Wherry, sp. nov.—Growing on limestone and in other circumneutral soils in the Appalachian Valley and adjacent portions of other provinces, there is another type of prickly pear, which lies in many respects intermediate between *O. compressa* and *O. humifusa* yet seems sufficiently distinct from either to justify its separation. Its characters are as follows:

Plants ascending, with fibrous roots. Joints oblong to obovate, mostly from 7 to 21 cm. long, 4 to 8 cm. wide, and 5 to 9 mm. thick; color a dull grayish yellow-green, ranging from about "chromium green" (31''i) on young joints bearing more or less glaucous coating, to "kronbergs green" (25''k) on old ones. Areoles few and widely spaced. Leaves spreading, early deciduous, 6 to 8 mm. long and 1.5 mm. thick, dull green-yellow, around "mignonette green" (25''i), toward the tip often of a dull orange-brown, such as "saval brown" (15''i) or a similar color. Spines none, except for a few small whitish ones on seedling plants. Glochids numerous, pale grayish orange-yellow approximating to "chamois" (19''b). Wool similar in hue to glochids, but paler, near "cartridge buff" (19''f). Flowers numerous, 7 to 10 cm. broad, opening during June; petals 10 to 14, pure yellow ("lemon yellow," 23). Stamens about 150, 1.5 to 1.8 cm. long; filaments somewhat more orange-colored than petals, often "lemon chrome" (21); anthers pale whitish yellow, "ivory yellow" (21''f). Style 1.8 to 2.2 cm. long, more or less yellow-colored, stigma lobes 3 mm. long, yellowish gray. Fruit slender obovoid, normally 3.5 to 4.5 cm. long by 1.2 to 1.5 cm. wide at the top, thus three times as long as thick; on ripening becoming dull grayish red, "hay's maroon" (1'm) and adjacent colors; seeds 4.5 to 5 mm. in diameter, 2.5 to 3 mm. thick, with an acute-edged keel rather less prominent than in its relatives, in color grayish orange-yellow, near "clay color" (17'').

As the type locality may be designated an occurrence on the west side of the

B. & O. R. R. tracks, a short distance north of Bolivar, Jefferson County, West Virginia. Type specimens, collected here on June 9, 1925, have been deposited in the U. S. National Herbarium (no. 1,242,156, type) and the New York Botanical Garden. The photograph reproduced as figure 1 was taken at that time and place, and brings out the lack of spines and the long fruit.

This plant has been thus far observed at the following localities. On limestone at two places about 2 km. (1.5 miles) north of Laray (in one locality covering several acres) and at Overall, Page County, Virginia, on brown shale (Devonian) at several places in the vicinity of Moorefield, Hardy County,



Fig. 1 *Opuntia calcicola* Wherry, new species

West Virginia, on shaly limestone along B. & O. R. R., at Martinsburg, Berkeley County, West Virginia; on dolomitic limestone near Bolivar, Jefferson Co., West Virginia (type locality), on red shale (Triassic) 6 km. (4 miles) south-southwest of Poolesville, Montgomery County, Maryland, and on limestone near Mechanicsburg, Cumberland County, Pennsylvania. Soil reaction ranging from specific acidity 10 to specific alkalinity 10, thus typically circumneutral. In the report on the Living Flora of West Virginia by Millsbaugh, published by the state in 1913, the occurrence at Moorefield is referred to in the tabulation (p. 309) as *Opuntia Opuntia*, but in the introduction (p. 15) as the western *Opuntia polyacantha*; as the latter species, true

to its name, bears numerous spines, while the West Virginia plant has none at all, this was a curious case of misidentification.

Opuntia calcicola differs, then, from its relative, *O. compressa*, in often growing on limestone, or in any case on rocks yielding circumneutral soils, in being more upstanding in habit, in having longer and relatively thinner joints of somewhat more bluish color, in the areoles being wide-spaced, and in lacking spines. The flowers are similar in color but larger, and the fruit is normally decidedly longer in proportion to its thickness, the seeds having a more acute and less prominent keel. Even allowing for some variation in these respects shown by the widespread *O. compressa*, the distinctness of the two seems evident. After the aspect of these plants is once in mind, as a result of observing them at one or two typical localities, it is possible to tell which is represented in a given colony from a considerable distance, and this may be regarded as a final criterion of the separateness of the species.

BOTANY.—*New plants from Chiapas collected by C. A. Purpus.*¹

PAUL C. STANDLEY, U. S. National Museum.

The nine species of plants here described as new form part of a large and interesting collection made in the State of Chiapas, Mexico, in 1925 by Mr. C. A. Purpus. Mr. Purpus' Mexican collections are too well known to need comment. Many of the new species found in them were described by the late Townshend S. Brandegee in a series of papers entitled "Plantae Mexicanae Purpusianae," the last of which was issued in 1924.²

***Neea chiapensis* Standl., sp. nov.**

Branchlets terete, pale brownish, minutely and densely grayish-puberulent at first but quickly glabrate; leaves opposite, or the upper verticillate, the petioles slender, 1.2–3 cm. long, glabrate, the blades elliptic or broadly elliptic, 7.5–15 cm. long, 4.5–7 cm. wide, abruptly acute or acuminate, at base acutish or abruptly acute, rarely rounded, thin, glabrous, the lateral nerves very slender, about 7 on each side, arcuate, laxly and irregularly anastomosing near the margin; pistillate inflorescence few-flowered, on a slender peduncle 5 cm. long; fruit elliptic-oblong, 18 mm. long, 9 mm. thick, the stone compressed, coarsely costate.

Type in the U. S. National Herbarium, no. 1,208,246, collected in a ravine in mountains east of Monserrate, Chiapas, Mexico, April, 1925, by C. A. Purpus (no. 271).

No. 414, from the same locality, is perhaps referable here, but in this the leaves are much smaller. The fruit is immature.

All the Central American species of *Neea* are closely related. This one is similar in most respects to *N. psychotrioides* Donn. Smith, but in that the leaves are relatively narrower and shorter-petioled, and the fruit only half as large.

¹ Published by permission of the Secretary of the Smithsonian Institution.

² Univ. Calif. Publ. Bot 10: 403–421.

***Zanthoxylum tenuipes* Standl., sp. nov.**

Branchlets unarmed or bearing stout broad-based prickles 1 cm. long; petioles terete, 2-3 cm. long; leaves odd-pinnate, the rachis setulose-hirtellous, the leaflets 5-9, opposite or the lower sometimes alternate, sessile or nearly so, ovate to oblong-elliptic, 3.5-6 cm. long, 1.5-3 cm. wide, acute or obtuse, thin, remotely and very shallowly glandular-crenate or subentire, deep green and somewhat lustrous above, paler beneath, sparsely setulose-hirtellous on both surfaces; inflorescences axillary, lax, few-flowered, paniculate, much shorter than the leaves, slender-pedunculate, the branches very slender, sparsely setulose, the pedicels almost filiform, 6-8 mm. long, glabrous; follicle 1, very oblique, produced at base, glabrous, coarsely glandular-punctate, 5 mm. long; seeds black and shining, 4 mm. long, sharp-edged.

Type in the U. S. National Herbarium, no. 1,208,237, collected in rocky gulch in mountains east of Monserrate, Chiapas, Mexico, July, 1925, by C. A. Purpus (no. 126).

Perhaps related to *Z. mollissimum* (Engelm.) P. Wilson, but easily recognized by the very long and slender pedicels and scant pubescence.

***Buddleia purpusii* Standl., sp. nov.**

Branches quadrangular, densely stellate-tomentose, the tomentum loose, whitish or fulvouscent, leaves sessile, lanceolate, 6-8.5 cm. long, 1.7-3 cm. wide, attenuate to an acute apex, cuneate at base, finely serrate-dentate with acute teeth, entire toward the base, green above, gland-dotted and rather finely stellate-tomentose, the venation impressed, beneath densely tomentose with a tomentum of loose whitish hairs, flowers sessile in dense few-flowered heads, the heads spikeate, the spikes panicle, spikes 2-5 cm. long, about 8 mm. thick, sessile, interrupted below, dense and continuous above, often branched; calyx densely stellate-tomentose, the lobes 1-1.5 mm. long, narrowly triangular; corolla densely tomentose outside, 2 mm. long, the lobes ovate-triangular, obtuse; capsule densely tomentose, equaling the calyx lobes.

Type in the U. S. National Herbarium, no. 1,208,235, collected along creek near Monserrate, Chiapas, Mexico, March, 1925, by C. A. Purpus (no. 160).

***Jacquemontia mollissima* Standl., sp. nov.**

Woody vine, the stems red-brown, with few large pale lenticels, when young densely stellate-tomentose with lax spreading hairs, petioles 3-7 mm. long, leaf blades ovate or oval-ovate, 1.5-3 cm. long, 1-2 cm. wide, acute to rounded at apex, sometimes apiculate, rounded or subcordate at base, above densely stellate-pilose, the hairs very slender, long, and soft, with few rays, beneath densely tomentose with long soft whitish hairs, flowers few, solitary or fasciculate in the leaf axils, the pedicels 2-3 mm. long, sepals 3-3.5 mm. long, oval or rounded, rounded at apex, the outer ones densely tomentose; corolla (probably white) 8-10 mm. long, glabrous.

Type in the U. S. National Herbarium, no. 1,208,236, collected on creek banks at Monserrate, Chiapas, Mexico, March, 1925, by C. A. Purpus (no. 47).

In general appearance this plant suggests *J. nodiflora* (Desr.) Don, but in that the sepals are glabrous, and the tomentum of the leaves fine and close.

***Columnnea purpusii* Standl., sp. nov.**

Small epiphytic shrub, the branches very stout, pale brownish or ochraceous, leafy near the tips, sparsely pilose with appressed or ascending hairs;

petioles 4-8 mm. long, densely villous-pilose with ascending, septate, whitish or purplish hairs; leaf blades narrowly elliptic-oblong or lance-oblong, 4-9.5 cm. long, 1-2 cm. wide, acute or acuminate, at base obliquely acute, glabrous above, beneath paler, sparsely setose-pilose along the nerves with pale appressed hairs, sometimes with a few appressed hairs between the nerves, the lateral nerves 3 or 4 on each side, ascending at an acute angle; flowers solitary in the leaf axils, the pedicels 4-12 mm. long, villous-pilose; calyx lobes narrowly lanceolate, rounded at base, 16-18 mm. long, 3-4 mm. wide, attenuate to an acute apex, ciliate, sparsely appressed-pilose outside, entire; corolla bright red, rather densely shorter-villous, the tube 4.5-5 cm. long, 7-9 mm. broad in the throat, the upper lip 2.5-3 cm. long, straight, the lower lip 1.5 cm. long, linear-lanceolate, recurved, the lateral lobes about 1 cm. long, obtuse; anther sacs 2.5 mm. long.

Type in the U. S. National Herbarium, no. 1,208,240, collected in damp forest in mountains near Fenix, Chiapas, Mexico, April, 1925, by C. A. Purpus (no. 239). No. 96 from the same locality also represents the species.

Only three species of *Columnnea* have been reported from Mexico. *C. flava* Murt. & Gal. has yellow flowers. *C. erythrophoea* Decaisne is closely related to *C. purpurea*, but has cordate and dentate, rose-colored calyx lobes. *C. schiedeana* Schlecht. is distinguished from the present plant by its spotted corolla and copiously pubescent leaves.

***Columnnea stenophylla* Standl., sp. nov.**

Small epiphytic shrub, the branches reddish or pale brownish, when young pilose with stiff, appressed or ascending, septate hairs, petioles stout, 3-5 mm. long, pilose, leaf blades linear-lanceolate to linear, 6-9.5 cm. long, 0.5-1.5 cm. wide, long-attenuate, obliquely acute at base, glabrous above, beneath paler, sparsely pilose with very slender, long, appressed, lustrous hairs, the lateral nerves inconspicuous; pedicels axillary, solitary, 4-8 mm. long, pilose with ascending hairs; calyx lobes lanceolate or linear-lanceolate, 15-18 mm. long, 2.5-5 mm. wide, long-attenuate, rounded at base, entire, green, densely appressed-pilose with very slender, whitish, multi-septate hairs, corolla bright red, densely villous with very long, slender, spreading, red hairs, the tube 4.5 cm. long, 9 mm. wide in the throat, the upper lip broadly oblong, rounded at apex, 3 cm. long, 1.3 cm. wide, the lower lip triangular-oblong, 1.5 cm. long, acutish, the lateral lobes obtuse, 1-1.5 cm. long.

Type in the U. S. National Herbarium, no. 567513, collected at Finca Irlanda, Chiapas, Mexico, June, 1914, by C. A. Purpus (no. 7206). Collected also at Cafetal Copalito, Oaxaca, May, 1917, by Blas P. Reko (no. 3894).

A relative of *C. purpurea* but distinguished by the narrow leaves and the long pubescence of the corolla.

The species of *Columnnea* are among the most beautiful plants of tropical America because of the large, brightly colored (usually red) flowers. Only a few species reach the mountains of southern Mexico, but in Costa Rica the genus attains probably its greatest development, and the number of species occurring there is very large.

***Hillia chiapensis* Standl., sp. nov.**

Small epiphytic shrub, glabrous throughout; stipules oblong to obovate, 3-4 mm. long, rounded at apex, caducous, petioles 2 mm. long or less; leaf

blades elliptic or oblong-elliptic, 9-14 mm. long, 4-7 mm. wide, rounded at apex, obtuse or acutish at base, fleshy, the lateral nerves inconspicuous, ascending at very acute angle; capsule subsessile, 17-22 mm. long, the valves after dehiscence 3-4 mm. wide.

Type in the U. S. National Herbarium, no. 1,208,244, collected in damp forest in mountains near Fenix, Chiapas, Mexico, April, 1925, by C. A. Purpus (no. 262).

Of the three other species of *Hillia* known from North America, only *H. tetrandra* Swartz could be confused with this Mexican plant. That species is much larger in all its parts, and I have no doubt that the Chiapas plant, although represented only by incomplete material, is specifically distinct.

Psychotria chlorobotrya Standl., sp. nov.

Branches green, subterete, glabrous, smooth; stipules distinct, green, herbaceous, persistent, glabrous, broadly triangular-ovate, 5 mm. long, bilobate to the middle, the lobes acute; petioles slender, 1.5-4.5 cm. long, remotely and minutely puberulent or glabrous; leaf blades narrowly elliptic to lance-elliptic or oblanceolate, 8-23 cm. long, 2-7 cm. wide, long-acuminate, acute at base or usually long-attenuate, thin, bright green above and glabrous, beneath slightly paler, glabrous or along the nerves sparsely and obscurely puberulent, the lateral nerves 12-16 pairs, divergent at an angle of 45° or more, arcuate, obscurely anastomosing near the margin, inflorescence terminal, cymose-paniculate, dense, many-flowered, the peduncles 2-3 cm. long, puberulent, the panicles 1.5-4.5 cm. long, the flowers in dense headlike cymes on puberulent peduncles 1 cm. long or shorter, bracts ovate, green, obtuse or acute, 5-8 mm. long; bractlets broadly ovate to obovate, obtuse, green, glabrous or nearly so, much exceeding the calyx; calyx about 2 mm. long, 5-lobate, the lobes about 1 mm. long, ovate or deltoid, obtuse or acute, unequal, green, glabrous; corolla salverform, 4 mm. long (not fully developed), glabrous, with short obtuse lobes.

Type in the U. S. National Herbarium, no. 1,208,242, collected in damp forest in mountains near Fenix, Chiapas, May, 1925, by C. A. Purpus (no. 104). No. 83, from the same locality, also is referable here.

The species is well marked among those of Mexico by the large green bractlets, which nearly conceal the flowers.

Psychotria phoeniciana Standl., sp. nov.

Branches subterete, glabrous; stipules persistent, intrapetiolar, bilobate, united, the sheath 3 mm. long, the lobes obliquely ovate or triangular, acute, glabrous; petioles slender, 2.5-5 cm. long, glabrous; leaf blades oblong-lanceolate to ovate-lanceolate, 10-17 cm. long, 3.5-4.5 cm. wide, acuminate, cuneate-acute at base or sometimes abruptly acute, thin, glabrous, slightly paler beneath, the lateral nerves about 17 pairs, divergent at an angle of about 60°, arcuate, laxly anastomosing near the margin; inflorescence terminal, glabrous, the peduncle 15 cm. long, curved, the flowers very numerous, corymbose-paniculate, the panicle much branched, 10 cm. long, 15 cm. broad, the pedicels slender, 10-15 mm. long; bracts triangular, acute, 1-2.5 mm. long, the bractlets minute; calyx limb scarcely 1 mm. long, 5-lobed to the middle, the lobes ovate, obtuse, glabrous; fruit oval, 5 mm. long, 4 mm. thick, 10-costate, the nutlets concave and sulcate on the inner face.

Type in the U. S. National Herbarium, no. 1,208,247, collected in damp forest in mountains near Fenix, Chiapas, Mexico, May, 1925, by C. A. Purpus (no. 316).

Although not marked by any outstanding characters, unless it be the large inflorescence and long pedicels, this plant seems distinct from any *Psychotria* of Mexico or Central America that is known to the writer.

ENTOMOLOGY.—*New termites from Guatemala, Costa Rica, and Colombia.* THOS. E. SNYDER, Bureau of Entomology, U. S. Department of Agriculture.

The seven new termites described in this paper were collected by Dr. W. M. Mann, of this Bureau, in the winter and spring of 1924, and by Mr. F. Neverman, of Costa Rica, late in 1924 and in 1925; a portion of this material has already been described.¹ In addition to descriptions of the new species, new geographical distribution records of known termites based on these collections are given.

Most of the new species represent "powder-post" termites or potential house termites, and may become of economic importance. The writer uses the term powder-post termites for certain groups in the family Kalotermitidae; the impressed pellets of finely digested, excreted wood fall from wood infested by these termites and reveal their presence. Such termites must be rigidly excluded and guarded against by Federal quarantines; they are likely to be introduced in furniture, and become cosmopolitan in distribution. *Kaloterмес* (*Cryptoterмес*) *brevis* Walker occurs from Florida in the United States to the West Indies, Central and South America, and South Africa.

Powder-post termites live in hard dry wood and are difficult to collect, hence, since they are not conspicuous, many new species are being found when specially sought after by such excellent collectors as Dr. Mann and Mr. Neverman. No single specimen was definitely designated as a holotype; since the specific descriptions were made from a series, these specimens are cotypes.

Family KALOTERMITIDAE

Kaloterмес (*Rugiterмес*) *costaricensis*, new species

Winged adult.—Head yellow-brown (light castaneous-brown), smooth, shining, longer than broad, sides almost parallel, rounded posteriorly, with fairly dense long hairs. Postclypeus white, tinged with yellow, short but broad. Labrum light yellow-brown, broader than long, broadly rounded to

¹ SNYDER, T. E.: *New American termites.* This JOURNAL 15: 152-162. 1925.

nearly straight at apex, with long hairs. Eye black, not round, fairly large and projecting, separated from lateral margin of head by a distance greater than the diameter of an eye. Ocellus hyaline, projecting, suboval, at an oblique angle to eye, from which it is separated by a distance equal to the long diameter of the ocellus.

Antenna light yellow-brown, whitish towards apex, with 17 to 20 segments; segments bead-like, or wedge-shaped, but becoming longer and broader toward apex; with long hairs; third segment longer than or subequal to second, but longer than fourth segment; last segment narrow, elongate, subelliptical.

Pronotum yellow (margins darker), not twice as broad as long, broadest at middle, roundly and shallowly concave both anteriorly and posteriorly; sides round, narrowed posteriorly, with scattered long hairs and denser short hairs.

Wings smoky dark brown, coarsely punctate. In forewing, median vein uniting almost directly with the radial sector; radial sector close to and parallel, and with seven branches to costal vein, first four long and oblique, others short; cubitus running parallel to radial sector, above middle of wing, to apex, with 11 branches or sub-branches to lower margin of wing; subcostal vein uniting with costa before middle of wing; seven irregular to crescentic transverse branches between cubitus and radial sector. In hind wing, median vein lacking; radial sector with two long and two short branches to costal vein; cubitus running to apex of wing with 10 branches or sub-branches to lower margin of wing; subcostal vein uniting with costa at about middle of wing; five irregular transverse branches between cubitus and radial sector.

Wing scale as long as pronotum.

Legs dark brown to fuscous (tarsi lighter), elongate, slender, hairs long.

Abdomen with tergites golden-yellow; tergites with fairly dense and fairly long hairs near base of each; cerci fairly elongate and prominent.

Measurements.—Length of entire winged adult, 11.5–12.25 mm.; length of entire deilated adult, 9–10 mm., length of head (to tip labrum), 2.1 mm., length of pronotum (where longest not at median line), 1.2 mm., length of forewing, 8 mm.; length of hind tibia, 1.5 mm.; diameter of eye (long diameter), 0.37 mm.; width of head (at eyes), 1.8 mm.; width of pronotum, 2.05 mm., width of forewing, 2.5 mm.

Soldier.—Head yellow-brown (light castaneous-brown, darker anteriorly and lighter posteriorly), cylindrical, markedly broadest anteriorly, sides slightly concave, with scattered long hairs, very dense on frontal slope or epicranial suture, where there is a median depression or groove. Eye spot hyaline, prominent, reniform, parallel to antennal socket. Gula about half as wide at middle as where widest anteriorly.

Mandibles black, base reddish-brown, broad at base, tips more slender, but fairly broad, pointed and incurved; left mandible with two fairly large sharp pointed marginal teeth on apical third, a small pointed tooth, a molar in the middle and a small blunt tooth near the base; right mandible with two large pointed marginal teeth, one in middle, the lower nearer the base; edge of right mandible roughened between apex and first tooth (Fig. 1).

Antenna yellow-brown to castaneous (lighter towards apex); with 15 segments, segments wedge-shaped, becoming longer and broader toward apex, with long hairs; third segment dark, markedly subclavate, longer than second or fourth segments; fourth segment about half as long as second; last segment elongate, slender, spatulate.

Pronotum yellow (margins darker), not quite twice as broad as long, broadest slightly anterior to middle; anterior margin broadly and roundly

concave; generally convex posteriorly except at middle where shallowly emarginate; sides narrowed posteriorly; pronotum with dense, fairly long hairs.

In some specimens, meso- and meta-nota with short wing pads.

Legs tinged with yellow; femora markedly swollen; three dark-colored spines at apex of tibiae.

Abdomen with tergites yellow to light yellow-brown; a row of fairly long hairs at base of each; cerci fairly elongate, styli present.

Measurements.—Length of entire soldier, 10–12.5 mm.; length of head with mandibles, 5.25 mm.; length of head without mandibles (to anterior margin), 3.5 mm.; length of left mandible, 1.8 mm.; length of pronotum, 1.45 mm.;



New species of *Kaloterмес* Mandibles of soldiers showing marginal teeth (Camera lucida, high power)

Fig 1 —*Kaloterмес* (*Rugiterмес*) *costaricensis* Snyder

Fig. 2 —*Kaloterмес* (*Calcariterмес*) *asperatum* Snyder

Fig 3 —*Kaloterмес* (*Calcariterмес*) *guatemalae* Snyder

length of hind tibia, 1.2 mm.; width of head (anteriorly), 2.1 mm.; width of head (posteriorly), 1.7 mm.; height of head at middle, 2 mm.; width of pronotum, 2.8 mm.

Type locality.—Hamburg Farm, Santa Clara Province, Costa Rica.

Described from a series of winged adults and soldiers collected with nymphs of the sexual form at the type locality on January 22, 1925, by Mr. F. Neverman in dead hardwood of *Manic*.

Co-types, winged adult.—Cat. No. 28655, U. S. N. M.; co-morphotypes, soldier.

The winged sexual adults of *K. (R.) costaricensis* are large and bicolored; and the soldier is also large.

***Kaloterмес* (*Calcariterмес*) *asperatum*, new species**

Winged adult.—Head castaneous-brown (lighter posteriorly and below eyes) smooth, shining, longer than broad, elongate, sub-oval, rounded posteriorly, a V-shaped marking at epicranial suture, with scattered, fairly long hairs. Eyes black, not round, but little projecting, separated from lower

margin of head by a distance less than the short diameter of an eye. Ocelli hyaline, suboval, close to eye.

Antenna light yellow-brown, with 12 segments, with long hairs; third segment subclavate, slender, longer than second or fourth segments; fourth segment bead-like; from fourth on segments becoming longer and broader toward apex; last segment elongate, slender, subelliptical.

Pronotum same color as head, shallowly concave anteriorly; posterior margin convex except for median emargination, sides narrow posteriorly; pronotum with scattered, long hairs.

Wings smoky, costal area darker (brown); tissue coarsely punctate, in forewing, median vein close to and parallel to subcosta, cubitus nearly in center of wing branching to apex, with about 11 to 12 branches or sub-branches to lower margin of wing; in hind wing, median branching from subcosta near base of wing.

Legs yellow (femora darker), slender, elongate; pulvillus present, legs with long hairs.

Abdomen with tergites castaneous-brown, a row of long hairs at base of each; cerci short, broad at base; styli present.

Measurements.—Length of entire winged adult, 5.8–6.2 mm.; length of entire deilated adult, 3.6 to 3.7 mm.; length of head (posterior margin to tip of labrum), 1.05 mm.; length of pronotum, 0.5–0.6 mm.; length of forewing, 4.2–4.3 mm.; length of hind tibia, 0.75–0.8 mm.; diameter of eye (long diameter), 0.25 mm.; width of head (at eyes), 0.75 mm.; width of pronotum, 0.7 mm.; width of forewing, 1.4 mm.

Soldier.—Head light castaneous-brown (with reddish tinge) to piceous on front (paler posteriorly), in profile head slightly concave in middle, short, cylindrical, front vertical to slightly projecting (overhanging) dorsally; head constricted (narrowed) dorsally at front, front scooped out; head with deep V-shaped median suture, lobes elevated, broadly rounded, and markedly roughened (tuberculate); head with transverse rows of long hairs anteriorly and in middle.

Eye spot not distinct, suboval. Gula blackish, not much narrowed in middle.

Mandibles blackish, short, broad at base, but pointed and incurved at apex; left mandible with two pointed marginal teeth near apex and a broad molar in middle; right mandible with two sharp-pointed teeth in middle (Fig. 2).

Antenna yellow-brown, with 10 segments, segments becoming longer and broader toward apex, with long hairs; third segment narrow, short, shorter than second or fourth segments; last segment slender, elongate, subelliptical.

Pronotum of same color as head; anterior margin deeply and roundly concave, roughened, with minute serrations or denticles; anterior corners high; posterior margin straight, except for median, round emargination, sides angularly narrow posteriorly.

Presternal processes dark colored.

Legs tinged with yellow; femora swollen; two chitinated spines and a spur at base of fore tibiae.

Abdomen with tergites yellowish, with a row of long hairs at base of each; cerci short.

Measurements.—Length of entire soldier, 3.8–4.7 mm.; length of head with mandibles, 1.55–1.75 mm.; length of head without mandibles (to anterior margin), 1.2–1.4 mm.; length of left mandible, 0.6 mm.; length of pronotum,

0.55–0.6 mm.; length of hind tibiae, 0.6 mm.; width of head (anteriorly), 0.85–1 mm.; width of head (posteriorly), 1–1.1 mm.; height of head at middle, 0.9–1. mm.; width of pronotum, 0.9–1 mm.

Type locality.—Hamburg Farm, Santa Clara Province, Costa Rica.

Described from a series of winged adults and soldiers collected with nymphs at the type locality by F. Neverman on May 15, 1925, in heartwood.

Co-type, soldiers.—Cat. No. 28658, U. S. N. M.; co-morphotypes, winged adult.

Kalotermes. (*C.*) *asperatum* is smaller than either *K.* (*Calcaritermes*) *imminens* Snyder and *recessifrons* Snyder from Colombia or *guatemalae* Snyder from Guatemala and Costa Rica.

***Kalotermes* (*Calcaritermes*) *guatemalae*, new species**

Winged adult.—Head very dark castaneous-brown (with reddish tinge), (lighter below the eyes and anteriorly), smooth, shining, longer than broad, (broadly suboval), rounded posteriorly, with few scattered short hairs, and a row of long hairs posteriorly. Eye black, not round, projecting, separated from lower margin of head by a distance about equal to half the short diameter of an eye. Ocellus hyaline, suboval, very close to eye.

Antenna yellow-brown near base, whitish with yellow tinge towards apex, with 13 segments; segments wedge-shaped to bead-like, becoming longer and broader toward apex; with long hairs; third segment subclavate, longer than fourth segment but approximately subequal to second; last segment elongate, subelliptical.

Pronotum of same color as head; anterior margin broadly roundly emarginate (shallowly concave); anterior corners high; sides roundly narrow towards posterior margin, which is nearly straight, short hairs on anterior margin, a row of long hairs just posteriorly to middle and on posterior margin.

Wings dusky brown (smoky), costal veins darker; membrane coarsely punctate, in forewing, median vein close and parallel to subcostal vein; cubitus in about middle of wing, branching to apex with about 12 branches or sub-branches to lower margin; in hind wing, median originates from subcosta near apex.

Legs with coxae and femora dark castaneous-brown; tibiae and tarsi white with yellow tinge, legs slender and elongate.

Abdomen with tergites dark castaneous-brown, with a row of long hairs at base of each, cerci fairly prominent; styli present.

Measurement.—Length of entire winged adult, 8–8.25 mm.; length of entire delated adult, 5 mm.; length of head (posterior margin to tip labrum), 1.4–1.45 mm.; length of pronotum, 0.7 mm.; length of forewing, 5.75 mm.; length of hind tibia, 1.1 mm.; diameter of eye (long diameter), 0.275 mm.; width of head (at eyes), 1.15–1.2 mm.; width of pronotum, 1–1.05 mm.; width of forewing, 1.8 mm.

Soldier.—Head castaneous-brown (lighter posteriorly and darker—to piceous—at anterior margin), elongate, cylindrical, thick, wider posteriorly than anteriorly, concave (dorsally) in middle in profile; head longer ventrally (2.40 mm.)—projecting to post-clypeus—than dorsally (2.25 mm.), where vertical; epicranial suture concave (hollowed out); head lobed medianly, a broad U-shaped cleft or suture, lobes but slightly roughened; head with few scattered long hairs. Eye spot hyaline, large, suboval, separated from antennal socket by a distance equal to its long diameter. Gula narrowed in middle.

Mandibles piceous, broad at base, sharp-pointed and incurved at apex; left mandible with three sharp-pointed marginal teeth, two near apical third, the other, larger tooth near middle; right mandible with two large pointed teeth near middle (fig. 3).

Antenna light yellow-brown near base (lighter anteriorly), with 12 segments; segments wedge-shaped, becoming longer and broader toward apex, with long hairs; third segment short, ring-like, shorter than second or fourth segments; last segment short, slender, suboval.

Pronotum castaneous-brown (margins darker), similar in shape to that of *K. (C.) emarginicollis* Snyder, but not quite so emarginate posteriorly, with scattered long hairs.

Legs tinged with yellow (femora darker and swollen); fore tibiae with spur.

Abdomen with tergites dirty white, tinged with yellow, a row of long hairs at base of each; cerci small; styli present.

Measurements.—Length of entire soldier, 6.5–7.5 mm.; length of head with mandibles, 3 mm.; length of head without mandibles (to anterior margin), 2.4 mm.; length of left mandible, 1 mm.; length of pronotum, 0.8–0.9 mm.; length of hind tibia, 0.9 mm.; width of head anteriorly, 1.5 mm.; width of head posteriorly, 1.7 mm.; height of head at middle, 1.4–1.5 mm.; width of pronotum, 1.5 mm.

Type locality.—Mixco, Guatemala.

Described from a series of winged adults collected with soldiers and nymphs at the type locality in May, 1924, by D. W. M. Mann. Other specimens of this termite (winged adults and soldiers) collected at Estrella, Costa Rica, in April, 1924, by Mann and soldiers at Bananito on April 20, 1925, by F. Neverman.

Co-type, soldier.—Cat. No 23657 U S. National Museum; co-morphotypes winged adult.

The soldier of *K. (C.) guatemalae* is similar to that of *K. (C.) emarginicollis* Snyder from Panama, but it is darker colored, larger, and has a wider head and a longer, and less deeply emarginate pronotum.

***Kaloterme* (*Calcaritermes*) *thompsonae*, new species**

Winged adult.—Head yellow-brown or light castaneous-brown (slightly immature), shining, sides parallel, approximately suboval, with scattered short hairs and row of longer hairs posteriorly. Eye black, not round, projecting, separated from lower margin of head by a distance less than long diameter of eye; ocellus hyaline, suboval, close to and at an oblique angle to eye.

Antenna light yellow-brown at base, yellow at apex, with 13 segments, segments wedge-shaped, becoming longer and broader toward apex, with long hairs; third segment subclavate, longer than second or fourth segments; last segment elongate, narrow, subelliptical.

Pronotum of same color as head, broadly and roundly concave anteriorly; posterior margin nearly straight; sides angularly narrow posteriorly; margins with scattered short and long hairs.

Wings hyaline (slightly immature) costal area yellow-brown; membrane coarsely punctate; in forewing, median vein close to and parallel to subcosta; cubitus in about middle of wing, branching to apex of wing; with 11–12 branches or sub-branches to lower margin of wing; in hind wing, median originating from subcosta near base.

Legs yellow, elongate, slender, pulvillus present, hairs long.

Abdomen with tergites light yellow-brown, a row of long hairs at base of each tergite, cerci short

Measurements—Length of entire winged adult, 7-7.5 mm., length of entire deilated adult, 4.3-4.6 mm. length of head (posterior margin to tip of labrum), 1.15-1.2 mm. length of pronotum, 0.5-0.55 mm., length of forewing, 5.4 mm., length of hind tibia, 0.7 mm., diameter of eye (long diam.), 0.25 mm., width of head (at eyes), 0.9 mm., width of pronotum, 0.85 mm., width of forewing, 1.5 mm.

The winged adult of *K (C) thompsonae* is lighter colored and smaller than either *imminens* Snyder or *recessifrons* Snyder from Colombia.

Soldier—Head castaneous to piceous on front, and yellow posteriorly, semicylindrical, nearly straight in profile, longer ventrally than dorsally, front of head with oblique slope, ventrally, seen from front, more or less shallowly concave, only slight outlines of a rim about median suture, which is broad, shallow, and V-shaped, lobes rounded and slightly roughened, with scattered short hairs anteriorly and a row of long hairs posteriorly. Eye spot indistinct. Gula narrowest at middle (where broadest in *K (C) recessifrons* Snyder from Colombia).

Mandibles piceous, short, broad at base, pointed and incurved at apex, left mandible with two sharp-pointed marginal teeth at apical third, another in middle. Right with two larger pointed marginal teeth near middle.

Antenna light yellow-brown, with 11 segments, segments wedge-shaped, becoming longer and broader toward apex, with long hairs, third segment ring-like, shorter than second or fourth segments, last segment slender, elongate, semi-elliptical.

Pronotum light yellow-brown (margins darker), short, nearly twice as broad as long, anterior margin broadly, roundly concave, anterior corners high, posterior margin shallowly concave in center, sides nearly straight, narrow posteriorly. Pronotum with but few scattered short hairs and a row of longer hairs posteriorly.

Presternal processes dark (yellow-brown).

Legs yellow, femora swollen, spur on fore tibiae.

Abdomen with tergites tinged with yellow, with a row of long hairs, cerci short.

Measurements—Length of entire soldier, 4 mm., length of head with mandibles, 1.8 mm., length of head without mandibles (to anterior margin ventrally), 1.5 mm., length of left mandible, 0.55 mm., length of pronotum, 0.5 mm., length of hind tibia, 0.55 mm., width of head anteriorly, 0.9 mm., width of head posteriorly, 0.95 mm., height of head (at middle), 0.8 mm., width of pronotum, 0.9 mm.

Type locality—Hamburg Farm, Santa Clara Province, Costa Rica.

Described from a series of winged adults and a soldier collected with nymphs at the type locality on May 29, 1925, by F. Neverman in dead dry wood of standing tree.

Co-type, soldier—Cat. No. 28658 U. S. National Museum, co-morphotypes winged adult.

The soldier of *K (C) thompsonae* has a shorter, more pointed mandible than in *recessifrons* Snyder and a shorter pronotum, it is smaller than *pergandiolae* Snyder from Panama.

Named in honor of the late Dr. C. B. Thompson of Wellesley College.

***Kaloterme* (*Glyptoterme*) *marlatt*, new species**

Winged adult.—Head light castaneous-brown, punctate, shining, sides parallel; head suboval, with scattered long hairs. Eye black, not round, projecting, separated from lower margin of head by a distance less than the diameter of an eye. Ocellus hyaline, suboval, close and at an oblique angle to eye.

Antenna yellow-brown, with 11 segments, segments bead-like, becoming longer and broader toward apex, with long hairs; third segment subclavate, slightly longer than second or fourth segment; last segment elongate, subelliptical.

Pronotum of same color as head, broadly roundly concave anteriorly; anterior corners high; straight at posterior margins; sides angularly narrowed posteriorly; pronotum with scattered long hairs.

Wings dusky with golden tinge (costal area yellow-brown), tissue coarsely punctate; in forewing, median vein close to and parallel to subcosta; cubitus in about middle of wing, branching to apex, with about 12 branches or subbranches to lower margin; in hindwing, median originating from subcosta near base (at about basal fourth of wing).

Legs yellow, elongate, slender, with long hairs.

Abdomen with tergites castaneous-brown, with a row of long hairs at base of each; cerci short.

Measurements.—Length of entire winged adult, 6.2 mm.; length of entire dealated adult, 4.5 mm.; length of head (posterior margins to tip of labrum), 0.9 mm.; length of pronotum, 0.45 mm.; length of forewing, 4.5 mm.; length of hind tibia, 0.6 mm.; diameter of eye (long diameter), 0.225 mm.; width of head (at eyes), 0.75 mm.; width of pronotum, 0.65 mm.; width of forewing, 1.2 mm.

The winged adult of *K. (G.) marlatt* is lighter colored than that of *barboursi* Snyder of Panama.

Soldier.—Head light castaneous-brown (darker—piceous—anteriorly and lighter posteriorly), slightly concave in middle in profile, slightly longer ventrally than dorsally, markedly narrowed or constricted dorsally at front, front darker, nearly vertical, a deep U-shaped median suture, lobes darker, raised and slightly roughened; head with two transverse rows of long hairs. Eye spot hyaline, suboval. Gula narrowed at middle.

Mandibles piceous, short, broad at base, sharp and incurved at apex; left mandible with two sharp-pointed marginal teeth on apical third, another near middle; right mandible with two larger, pointed teeth near middle.

Antenna light yellow-brown, with 10–11 segments, segments wedge-shaped, becoming longer and broader toward apex, with long hairs; third segment small, ring-like; last segment slender, elongate, subelliptical.

Pronotum of same color as head, broadly roundly concave anteriorly, nearly straight at posterior margin, anterior corners high, sides narrow posteriorly, margins with long hairs.

Presternal processes light yellow-brown.

Legs yellowish, femora swollen, three castaneous chitinized spines at base of fore tibiae; legs with long hairs.

Abdomen with tergites dirty gray-white with yellowish tinge, with a row of long hairs on each; cerci fairly elongate.

Measurements.—Length of entire soldier, 4.25 mm.; length of head with mandibles, 1.65 mm.; length of head without mandibles (to anterior margin), 1.25 mm.; length of left mandible, 0.55 mm.; length of pronotum, 0.5 mm.; length of hind tibia, 0.5 mm.; width of head anteriorly, 0.75 mm.; width of

head posteriorly, 0.85 mm.; height of head (at middle), 0.75 mm.; width of pronotum, 0.8 mm.

Type locality.—Hamburg Farm, Santa Clara Province, Costa Rica.

Described from a winged adult and a soldier collected at the type locality by F. Neverman, February 1, 1925, in hardwood of Manú.

Co-type, soldier.—Cat. No. 28659 U. S. N. M.; co-morphotype, winged adult.

The soldier of *K. (G.) marlatti* is smaller than that of *angustus* Snyder of Panama; is close to *barbouri* Snyder but the head is not so high, and the marginal teeth on the left mandibles are sharp pointed and not molar, and also the pronotum is of slightly different shape.

Named in honor of Dr. C. L. Marlatt of the Federal Horticultural Board who carefully guards the United States against importation of foreign termites.

***Kalotermes (Glyptoterme) nevermani*, new species**

Soldier.—Head light yellow, darker (yellow-brown) anteriorly, longer than broad, cylindrical, only slightly broader posteriorly than anteriorly, front obliquely, angularly sloping, a broad, rounded suture medianly, margins of lobes rounded, but slightly roughened, slightly elevated; head with several transverse rows of long hairs. Eye spot hyaline, large, suboval. Gula elongate, about half as wide in middle as where widest anteriorly.

Mandibles dark reddish-brown to piceous at tips, broad, narrowed, pointed and incurved at tips; left mandible with one pointed marginal tooth near apex, a molar with sharp point anteriorly and broader molar, right mandible with sharp-pointed tooth near middle and molar about as in *K. (G.) suturis* Snyder.

Antenna light yellow, (darker near base), with 10 to 12 segments, usually 11, segments becoming longer and broader (wedge-shaped) toward apex, with long hairs; third segment short, ring-like, shorter than second or fourth segments; last segment slender, elongate, subelliptical.

Pronotum yellow (margins darker), broadly and shallowly concave anteriorly, posterior margin nearly straight, anterior corners high, sides angularly narrowed posteriorly; hairs scattered, and long.

Presternal processes yellow.

Legs whitish, tinged with yellow, femora swollen, with long hairs.

Abdomen gray-white, with a row of long hairs at the base of each tergite, cerci fairly elongate; styli present.

Measurements.—Length of entire soldier, 5–6.25 mm.; length of head with mandibles, 2.5–2.7 mm.; length of head without mandibles (to anterior), 1.8–1.9 mm.; length of left mandible, 0.95 mm.; length of pronotum, 0.6–0.7 mm.; length of hind tibia, 0.9 mm.; width of head (dorsally) anteriorly, 1.2 mm.; width of head posteriorly, 1.25 mm.; height of head in middle, 1.2 mm.; width of pronotum, 1–1.05 mm.

Type-locality.—Western slope of the volcano Irazú, at 1500 meters, Costa Rica.

Described from three soldiers, collected with nymphs at the type locality by F. Neverman on February 22, 1925, in a dry stump.

Co-type, soldiers.—Cat. No. 28660 U. S. N. M.

Kaloterme (G.) nevermani is close to *K. (G.) suturis* Snyder, also from Costa Rica, but is larger and has more segments to the antenna; the winged adult is unknown.

Family TERMITIDAE

Capritermes (*Neocapritermes*) **longinotus**, new species

Soldier.—Head yellow to pale yellow-brown, darker anteriorly and on sides, with a distinct dark median line running from posterior margin to epicranial suture, sides nearly parallel, but head broader posteriorly than anteriorly, rounded posteriorly, with fairly dense long hairs, especially anteriorly. Labrum of same color as head, elongate and faintly trilobed, broad at apex, narrowed in middle, long hairs on median lobe. Gula elongate, slender, about half as wide in middle as where widest anteriorly. Mandibles black, twisted, asymmetrical; left mandible longer than right.

Antenna yellow, with 16 segments, segments becoming longer and broader toward apex, longest in middle, with long hairs; third segment shorter than second, but approximately subequal to fourth segment, or slightly shorter; segments becoming markedly longer from seventh to twelfth segments, then becoming shorter; last segment elongate, slender, subelliptical.

Pronotum white with tinge of yellow, darker on anterior margin, very elongate anteriorly, high (saddle-shaped), and markedly roundly emarginate, hairs dense, and long.

Legs tinged with yellow, elongate, slender, with long hairs.

Abdomen dirty white, tinged with yellow, tergites with fairly dense long yellow hairs; cerci not elongate.

Measurements.—Length of entire soldier, 7.75–8 mm.; length of head with mandibles, 4.6 mm.; length of head without mandibles (to anterior margin), 2.4 mm.; length of left mandible, 2.2 mm.; length of pronotum, 0.85 mm.; length of hind tibia, 1.25 mm.; width of head (anteriorly), 1.3 mm.; width of head (posteriorly), 1.4 mm.; height of head at middle, 1.2 mm.; width of pronotum: 1.05 mm.

Type locality.—Rio Frío, Colombia.

Described from four soldiers collected with workers by Dr. W. M. Mann in February, 1924, at the type locality.

Co-type, soldiers.—Cat. No. 28661, U. S. N. M.

Capritermes (*N.*) *longinotus* is a very small species with a narrow head and a very long pronotum, which is markedly roundly, emarginate anteriorly; the winged adult is unknown.

LIST OF KNOWN OR DESCRIBED TERMITES COLLECTED BY MANN AND NEVERMAN
IN GUATEMALA, COSTA RICA AND COLOMBIA

Family KALOTERMITIDAE

Cryptotermes dudleyi Banks.

COSTA RICA:—San Jose, May 5, 1925, F. Neverman, colr. (winged adults flying at light in house)

Family RHINOTERMITIDAE

Coptotermes niger Snyder

Guatemala, Bobas; May, 1924, Dr. W. M. Mann, colr. (soldiers and workers).

COSTA RICA, Colombianas; March, 1924, Dr. W. M. Mann, colr. (soldiers and workers). Hamburg Farm, Feb., 1925, F. Neverman, colr. (soldiers and workers); June 2, 1925 (winged soldiers and workers). Bananito, April 20, 1925, F. Neverman, colr. (soldiers and workers).

Prorhinotermes molinoi Snyder

COSTA RICA, Parisiana Ranch; Feb. 6, 1925, F. Neverman, colr. (soldiers and workers in rotten log).

Family TERMITIDAE

Cornitermes acignathus Silvestri

COLOMBIA, Santa Anna, Feb., 1924, Dr. W. M. Mann, colr. (soldiers and workers).

Armitermes chagresi Snyder

COSTA RICA, Hamburg Farm; Jan., 1925, F. Neverman, colr. (soldiers and workers).

Nasutitermes (Nasutitermes) columbicus Holmgren

COSTA RICA, Hamburg Farm; Jan., 1925, F. Neverman, colr. (soldiers and workers).

Nasutitermes (Nasutitermes) rotundatus Holmgren

COLOMBIA, Rio Frio; March, 1924, Dr. W. M. Mann, colr. (soldiers and workers).

Nasutitermes (Oblutitermes) panamae Snyder

COLOMBIA, Rio Frio; Feb., 1924, Dr. W. M. Mann, colr. (two types of soldiers and workers).

Amitermes beaumonti Banks

GUATEMALA, Mixco, May 1924, Dr. W. M. Mann, colr. (soldiers and workers).

Microcerotermes exiguus Hagen

COLOMBIA, Santa Anna, Feb., 1924, Dr. W. M. Mann, colr. (queen, soldiers and workers).

SCIENTIFIC NOTES AND NEWS

The following lectures have been given in the Carnegie Institution's series since the last record in this JOURNAL: November 24, DR. ARTHUR L. DAY of the Geophysical Laboratory, *The Santa Barbara earthquake*; December 1, DR. HARALD U. SVERDRUP of Captain Amundsen's "Maud" Arctic-Drift Expedition, cooperating with the Department of Terrestrial Magnetism, *The scientific work of the "Maud" expedition, 1922-1925*; December 8, DR. ARTHUR S. KING of the Mount Wilson Observatory, *Laboratory methods of analysing spectra, with application to atomic structure*.

ERNEST F. BURCHARD of the U. S. Geological Survey has returned from a trip across South America from the Pacific to the Atlantic Coast, having examined iron-ore deposits in Misiones Territory and in Catamarca Province for the Argentine Government. On his return journey he visited the principal iron and manganese-ore deposits in central Minas Geraes, Brazil.

T. S. LOVERING has been appointed Junior Scientist in the Geological Survey.

The 1925 exhibition of current scientific work of the Carnegie Institution of Washington held during December 11 to 14 was attended by over 2,300 visitors. The exhibits shown may be classed into four groups: (1) Original materials or photographs of such materials on which research work was done; (2) methods, especially instrumental, for solving such problems; (3) models and simple experiments illustrating the principles on which a research problem is based; (4) tables, graphs, models, and other means of presenting results obtained by research work.

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

VOL. 16

JANUARY 19, 1926

No. 2

GEODESY.—*The deflection of the vertical in Porto Rico.* WILLIAM BOWIE, U. S. Coast and Geodetic Survey.

Island masses furnish numerous cases of large deflections of the vertical by which the distribution of densities in the earth's crust may be studied. A notable case is in the island of Porto Rico in the West Indies. Astronomic latitude stations on the south and the north coasts are connected by triangulation. The difference in the astronomic latitudes is $35^{\circ} 36'' .00$ while the difference in the latitude of the astronomic stations as derived from the distance between them obtained by triangulation is $34^{\circ} 40'' .20$. The difference between these two values is $55'' .80$, or about one statute mile. This value is the relative deflection of the vertical. Since the plumb line at each of the stations is attracted by the island mass and repelled by the deficiency of mass in the space occupied by water in the Atlantic Ocean or in the Caribbean Sea, it is certain the direction of the plumb line at each station is affected.

TABLE 1—ISOSTATIC REDUCTIONS OF TWO STATIONS IN PORTO RICO

STATION	EFFECT OF TOPOGRAPHY ALONE	EFFECT OF TOPOGRAPHY AND COMPENSATION TO DEPTHS OF			
		96 km	130.9 km	168.9 km	231.2 km.
	seconds	seconds	seconds	seconds	seconds
Muertos Island Light House on south coast.....	-0 65	-18.83	-20.84	-22.92	-24.65
San Juan Light House on north coast.....	+74 63	+20.37	+23.26	+26.93	+31.35
Combined effect at the two stations..	75 28	39 20	44.10	49.85	56 00

The isostatic reductions of the two latitude stations were made by Messrs. C. H. Swick and W. D. Lambert of the Coast and Geodetic Survey with the results shown in table 1.

The densities below the surface of the island are not known, and, of

course, there is no way of learning by direct means the density of the crust under the water surrounding Porto Rico. In the computations the density of the mass above sea level was taken as 2.67, this being the value adopted and used in the isostatic reductions by the U. S. Coast and Geodetic Survey.

The most probable depth of compensation resulting from isostatic investigation by that Bureau is 96 kilometers. But with that depth, applied to Porto Rico, the effect of topography and compensation is only $39''.20$, or $16''.60$ less than the relative deflection of the vertical between the two stations.

If the astronomic work and the triangulation were perfect, the crust in perfect isostatic equilibrium, the density conditions as used in the computations true and no errors exist in map readings, then the depth to which the compensation is distributed under and around the island would be about 230 kilometers. The combined topographic and compensation effect for the two stations is $56''.00$ for the depth 231.3 kilometers, used in the computations.

Since the computed deflection to the south for the San Juan station, and that to the north for the Muertos station are too small to account for the observed combined deflection, we must conclude that there is something abnormal about the Porto Rico region. It does not seem to be probable that the depth of compensation in the region is as much as 230 kilometers. This is nearly two and one-half times the depth derived for the area of the United States. The astronomic work is believed to be very accurate, while the distances by triangulation are correct. There is no detailed topographic map of the island, nor are the depths of the surrounding waters given in much detail. Some error in the computed effects may be due to erroneous map and chart data, but probably not very much. No definite conclusions are possible as to the cause of the Porto Rican deflection remaining after the corrections for topography and compensation have been applied.

The density of the materials of the crust to the north and to the south of the island seems to be too low. That is, the normal density of the crust augmented by the compensation distributed to a depth of 96 kilometers is greater than the excess of deflection indicates to be the case. Or it may be that the crust under the water areas is normal in density, but that the upper crust under the island is excessively dense.

If the compensation of the island material is regionally distributed horizontally throughout the pedestal on which the island stands, the effect of the compensation of the island would be such as to increase the

deflection of the plumb line at the two stations toward the island, thus making for closer agreement between the computed and observed deflections.

While the application of the isostatic method with a depth of 96 kilometers leaves a residual of 16'' 60, and with depth of 120 9 kilometers a residual of 11' 70, the residual found by applying the effect of topography alone is 19'' 48. All of these residuals are of the same order of magnitude.

It would seem that the region around Porto Rico, if in isostatic adjustment and if densities are otherwise normal, has a great depth of compensation or, if in isostatic equilibrium at depth of about 100 kilometers, there is very irregular distribution of densities near the surface under the island and also under the adjacent water areas. The other condition might be absence of isostatic equilibrium of the region, but with isostasy applied the computed deflection is smaller than the observed value, while by applying the topographic effect alone the computed value is larger than the observed one. The writer favors the view that the cause is abnormally heavy rock in the upper crust just below the island, but no definite conclusions should be drawn until we shall have accurate topographic maps of the island and charts of the extensive water areas to the north and south of the island. When they are available a revised computation will be made.

CHEMISTRY—*2-thio-3-(2-p-xyldyl) 4-keto thiazolidone and some of its derivatives*¹ RAYMOND M. HANN, George Washington University (Communicated by Edgar T. Wherry)

In previous papers of this series the reactions of 2-thio-3-aryl-4-thiazolidones (rhodanic acids) with isatin² and with halogen substituted 3-methoxy-4-hydroxy benzaldehydes³ have been reported. During the course of the above mentioned investigations several new thiazolidones were prepared in pure condition and the purpose of the present paper is to record the preparation and properties of 2-thio-3-(2-p-xyldyl)-4-thiazolidone and some of its derivatives.

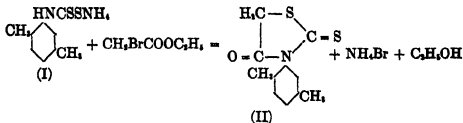
The synthesis of 2-thio-4-thiazolidones, commonly known as rhodanic acids, and in reality the anhydrides of di-thio carbamio thio glycollic acids, is easily effected through the interaction of the ammonium salt of a substituted dithiocarbamic acid with an α -halogen substituted monocarboxylic acid. In the present instance ammonium

¹ Contribution from the Chemical Laboratory of the George Washington University.

² Hann, Journ. Am. Chem. Soc. 47 1189 1925.

³ Hann, Journ. Am. Chem. Soc. 47 1998. 1925.

2-p-xyldyl dithiocarbamate (I) was allowed to react with brom acetate ester, when ammonium bromide and ethyl alcohol were eliminated with subsequent ring closure to form the 2-p-xyldyl thio thiazolidone (II).



Attention has previously been called to the marked activity of the methylene hydrogen of keto thiazolidines due to the CO-CH₂-S linkage. In common with other members of the series the 2-p-xyldyl homologue reacts readily with aldehydes to give beautiful crystalline derivatives which act as weak yellow dyes. These compounds are insoluble in water, but dissolve in concentrated sulphuric acid with the production of brilliant red colors. In this paper are described the benzilidene, cinnamylidene, vanillidene, 5-brom vanillidene and dibrom phenyl propionilidene derivatives.

EXPERIMENTAL

Ammonium-2-p-xyldyl dithiocarbamate—Forty-five grams of 2-p-xyldine* (boiling point 215–4°C), 60 cc of strong ammonium hydroxide and 30 grams of carbon disulfide were mixed. Upon vigorous agitation the mixture gradually warmed up and finally resulted in a clear red oil. Upon standing overnight some slight separation of a yellow crystalline material had taken place. This was crushed and the now viscous solution thoroughly stirred and placed in cold storage room (–10°C) for 24 hours. At the end of this period of time an abundant separation of the desired salt had occurred. This was filtered off by suction and dried on the filter. The yield amounted to 58 grams which is approximately 80 per cent of that required by theory.

Ammonium 2-p-xyldyl dithiocarbamate is a slightly yellow crystalline solid, possessing a marked somewhat disagreeable odor. It is soluble in water and alcohol, but can not be recrystallized from these solvents due to decomposition. Upon standing in the air it gradually decomposes, yielding a yellow oil.

2-thio-5-(2-p-xyldyl)-4-keto thiazolidine—Fifty-eight grams of ammonium 2-p-xyldyl dithiocarbamate was suspended in 50 cc of absolute ethyl alcohol and to the suspension 45 grams of mono brom

* The 2-p-xyldine was prepared by J. F. T. Berliner of the Graduate School of the George Washington University.

ethyl acetate rapidly added. An exothermic reaction took place at once and the flask containing the reaction mixture was placed under a reflux condenser to prevent loss of its volatile constituents. Ammonium bromide separated and the flask contents boiled vigorously. When the violence of the original reaction had somewhat abated, heat was applied and the suspension gently refluxed for a period of five hours. After standing overnight, an excess of water was added, causing the separation of a heavy yellow oil. This oil was washed thoroughly with water to remove ammonium salts, then with sodium carbonate solution and finally again with water. Upon standing for a week a considerable portion had solidified. The solid portion was filtered off and the residual oil worked up for more of the reaction product. The total yield was 44 grams, which is 70 per cent of theory.

Thio-3-(2-p-xylydyl)-4-keto-thiazolidine is a yellow crystalline solid, readily soluble in acetic acid and alcohol, practically insoluble in water. When heated in a capillary tube it melts at $119-20^{\circ}\text{C}$. (corrected) to a clear light yellow oil.

Analysis: 0.1040 gram consumed 4.4 cc. $\frac{N}{V}$ acid (Kjeldahl-Gunning Arnold method) = 5.93 per cent N. Theory for $\text{C}_{11}\text{H}_{11}\text{ONS}_2$ = 5.91 per cent N.

2-thio-3-(2-p-xylydyl)-5-benzal-4-thiazolidone.—Three grams of 2-thio-3-(2-p-xylydyl)-4-thiazolidone, 1.5 grams of benzaldehyde and 5 grams of fused sodium acetate were refluxed with 25 cc. of glacial acetic acid for $2\frac{1}{2}$ hours. After cooling an excess of water was added and the precipitated condensation product was filtered by suction and recrystallized twice from glacial acetic acid. The yield was quantitative.

The 2-thio-3-(2-p-xylydyl)-5-benzal-4-thiazolidone is a brilliant yellow crystalline compound, readily soluble in hot glacial acetic acid and only sparingly so in cold. The compound dissolves in concentrated H_2SO_4 with production of a brilliant red color. When heated slowly in a capillary tube it melts at $188-9^{\circ}\text{C}$. (corrected) to a clear yellow oil.

Analysis: 0.1061 gram consumed 3.2 cc. $\frac{N}{V}$ acid (Kjeldahl-Gunning Arnold method) = 4.22 per cent N. Theory for $\text{C}_{12}\text{H}_{11}\text{ONS}_2$ = 4.31 per cent N.

2-thio-3-(2-p-xylydyl)-5-cinnamal-4-thiazolidone.—Three grams of the xylydyl cyclic ketone, 1.7 grams of cinnamic aldehyde, 5 grams of fused sodium acetate and 25 cc. of glacial acetic acid were refluxed for about

an hour. The condensation product separated after 10 minutes of heating. After cooling an excess of water was added to the reaction mixture, the precipitated solid was filtered off and recrystallized from 75 cc. of glacial acetic acid. The yield was quantitative.

Thio-3-(2-p-xylyldyl)-5-cinnamal-4-thiazolidone is a solid, crystallizing in beautiful brilliant needles of an orange yellow color. It is soluble in glacial acetic acid and insoluble in water. Heated in a capillary tube it melts at 194–5°C. (corrected) to a clear yellow oil.

Analysis: 0.0982 gram consumed 2.8 cc. of $\frac{N}{10}$ acid (Kjeldahl-Gunning Arnold method) = 3.99 per cent N. Theory for $C_{19}H_{17}ONS_2$ = 3.99 per cent N.

2-thio-3-(2-p-xylyldyl)-5-(α β dibrom- β -phenyl propional)-4-thiazolidone.—The mother liquors from the recrystallization of the cinnamildene derivative were cooled in an ice salt bath and bromine vapors passed over the solution. An immediate precipitation of an orange yellow solid occurred at the liquid surface. To complete the reaction an excess of bromine dissolved in glacial acetic acid was added. The precipitated solid was filtered by suction and dried, when it was obtained as a yellow brown powder. Upon heating in a capillary tube it melted, after preliminary softening, at 119–20°C. (corrected) with decomposition.

Analysis: 0.1130 gram consumed 2.3 cc. $\frac{N}{10}$ acid (Kjeldahl-Gunning Arnold method) = 2.85 per cent N. Theory for $C_{20}H_{17}ONS_2Br_2$ = 2.74 per cent N.

2-thio-3-(2-p-xylyldyl)-5-vanillal-4-thiazolidone.—This derivative was prepared by the general method used above, from 3 grams of the thiazolidone and 1 gram of 3-methoxy-4-hydroxy-benzaldehyde.

Thio-3-(2-p-xylyldyl)-5-vanillal-4-thiazolidone crystallizes in flower-like clusters of bright yellow needles. It is soluble in hot acetic acid and in alcohol, but insoluble in water. It is also soluble in concentrated sulphuric acid with production of a brilliant red color. It melts at 155–6°C. (corrected) to a clear yellow oil.

Analysis: 0.1137 gram consumed 3.0 cc. $\frac{N}{10}$ acid (Kjeldahl-Gunning Arnold method) = 3.69 per cent N. Theory for $C_{19}H_{17}O_2NS_2$ = 3.77 per cent N.

2-thio-3-(2-p-xylyldyl)-5-(5-brom-vanillal)-4-thiazolidone.—The condensation of the brom substituted vanillin was carried out in the usual manner. This compound crystallizes in compact masses of golden brown glistening crystals, which yield a bright yellow powder when crushed. The compound dissolves in sulphuric acid with development

of a bright red color. It melts at 192.3° (corrected) to a clear deep yellow oil.

Analysis: 0.1468 gram consumed 3.3 cc. N_2 acid (Kjeldahl-Gunning Arnold Method) = 3.15 per cent N. Theory for $C_{19}H_{16}O_3NS_2Br$ = 3.11 per cent N.

SUMMARY

2-thio-3-(2-p-xylydyl)-5-thiazolidone has been synthesised.

Its condensation products with benzaldehyde, cinnamaldehyde, vanillin, 5-brom vanillin and $\alpha\beta$ dibrom β phenyl-propionaldehyde have been prepared and described.

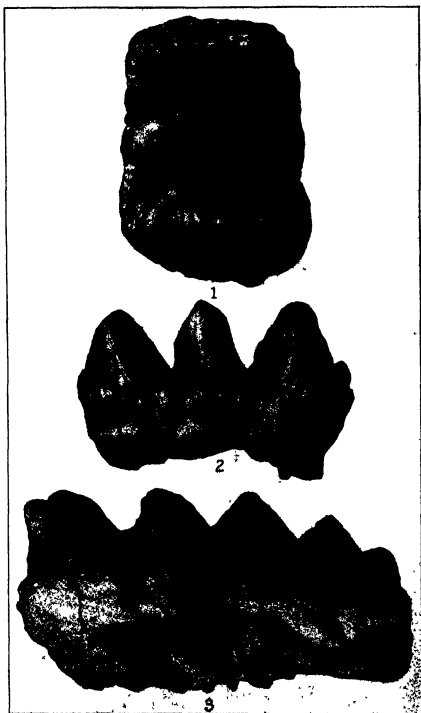
PALEONTOLOGY.—*Two new Pleistocene mastodons.* OLIVER P. HAY, Carnegie Institution of Washington.

On examining a collection of the teeth which are identified as those of *Mammot americanum*, one is surprised to see the great amount of variation among them; variation in size, in width relative to the length, height of the cones of cross-crests, roughness or smoothness of the enamel, number of cross-crests in the hindmost molars, development of the talons, strength of the crests (*cristae*) which descend from the summits of the principal cones into the valleys, and various other features. One is compelled, too, to recognize the frequent intergradations among these various molars; and one is led to wonder whether one highly variable species is represented or whether a number of closely related forms are indicated. Apparently nobody has yet undertaken to connect the differing molars with geographical regions or with geological horizons.

The writer has before him two molars which he ventures to describe as new species.

Mammot francisi, new species (Fig. 3 and 4)

The writer has received for examination, from Dr. Mark Francis, College Station, Texas, a tooth of a mastodon which presents a number of peculiarities and which appears to be worthy of description and a distinctive name. This tooth was found in Brazos River, at Pittbridge, Burleson County. It is the upper right third molar and had not yet begun to wear. One striking feature is the great width of the tooth. It is possible that this is abnormal, but there is no indication of it, and a tooth of *M. americanum* at hand is as wide at the first two crests, but does not diminish so much in width at the third and



Figs. 1 and 2 *Mammot oregonense*. Type. $\times 0.65+$. 1 View of grinding face. 2. View of inner face. Fig 3 *Mammot francisi*. Type. $\times 0.71+$. View of outer face.

fourth crests. The total length is 147 mm. the width taken at the first and second cross crests is 100 mm. At the third and fourth



Fig 4 *Mastomys* *pygmaeus* ×1 View of grinding face

cross-crests the width is respectively 86 mm. and 70 mm. It may be said that there is a small fifth crest, only the pretrite portion of which is developed. Behind this is what may be regarded as a small talon. The buccal border of the tooth is straight; the lingual border, strongly convex. One might expect the reverse condition.

Around the base of the crown is a cingulum, showing especially in front and at the ends of the valleys, small on most of the ends of the crests. In all of the valleys is a thick deposit of cement, and this covers the slopes of the cross-crests almost to their summits, (fig. 4). The enamel is white; the cement is stained brown. The bases of the roots, as seen in figure 3, are covered with cement.

The crown is of moderate height. The following are the measurements of the cones taken along the slopes from the base of the crown. On the posttrite side these measurements differ but little from the perpendicular height; on the pretrite side they are greater, because of the lesser slope.

Heights of cones of cross-crests are as follows:

Posttrite		Pretrite	
	mm		mm
1	57	1	71
2	56	2	67
3	50	3	65
4	47	4	55
		5	57

The pretrite cones possess conspicuous front and rear crests, or ridges, which descend into the valleys from the apex of each cone. These ridges are exaggerations of those found in most teeth of *Mammot americanum*, but they are in some cases even surpassed in teeth which pass for those of the species last mentioned. From the summit of the principal cone of the posttrite half of the cross-crests, a less prominent ridge descends to the valley on each slope; also from the secondary cone of this half, a feeble ridge or welt is sent down in front and behind. What especially characterizes the tooth from Pittbridge, aside from its shortness and width, is the extent to which the valleys are blocked up by the bases of the cross-crests. The heights of the first and second pretrite cones are 71 mm. and 67 mm. respectively. From a line joining their summits the first valley is not more than 20 mm. deep; the second valley is 15 mm. deep. The shallowness of the valleys is shown by figure 3. Notwithstanding the great width of the tooth the distance apart of the apices of the pretrite and posttrite cones is small, 40 mm., 39 mm., 35 mm., 30 mm., respectively from

the first to the fourth cross-crests. That part of the cross-crests between the principal cones is sharp and the conules usually present in *Mammut americanum* are feebly or not at all developed.

An upper left third molar of *Mammut americanum* (Cat. no. 335, U. S. Nat. Mus.), said to have been found in alluvial banks of the Susquehanna River, is 175 mm. long and 102 mm. wide at the second cross-crest. It has strong descending ridges on the faces of the pretrite cones, weak ones on the cones of the other half of the cross-crests. The whole crown is rough with welts and small knobs. At the ends of the valleys are large conules. On the summit of the posttrite half of each cross-crest is a row of four or five conules; others less distinct on the pretrite side. The cones are high, the second about 73 mm. The valleys, where the descending ridges meet, are 30 mm. from the summits of the cones in the first and second valleys.

Believing that the tooth here described from Pittbridge represents a species of *Mammut* not hitherto recorded and wishing to honor the finder, the writer proposes to call it *Mammut francisi*.

Mammut oregonense, new species (Fig. 1, 2)

In the U. S. National Museum is a mastodon tooth (Cat. no. 4911) which was sent there in November, 1900, by Dr. Waldemar Lindgren, from Baker City, Baker County, Oregon. It had been found by the Cartwright Brothers, placer miners, at Rye Valley, on Dixie Creek, in township 13 south, range 43 east. Dr. Lindgren reported that the tooth had been found in a fluvial clay bed which had formed a part of a bench of auriferous gravels, overlying the Payette beds. He regarded the fluvial clay as of Pliocene age. It appears more probable that the bed belonged to the Pleistocene, for in it was discovered a tooth of *Elephas columbi*.

With this tooth came another of *Mammut* (Cat. no. 4912), a well-worn fragment of the rear of M_2 of left side, showing 2 cross-crests, width 68 mm. It may or may not belong to *M. oregonense*. The type tooth here described and figured is the upper left second molar. It has been regarded as belonging to *M. americanum*, but it is so different that the writer ventures to give it a distinct name.

The tooth had apparently not yet begun to suffer wear; or, if at all, only slightly on the first cross-crest. The length is 111 mm.; the width of the front end, 74 mm.; of the rear end, 80 mm. The crown presents 3 cross-crests and, in the rear, a talon. The crests are high, and the valleys narrow. The ends of the cross-crests slope steeply

and nearly equally. The summits of the two principal cones of each crest are well separated, as follows: First crest, 38 mm., second, 40 mm., third, 40 mm.

The heights of the principal cones from the base of the crown are as follows:

Pretrite		Posttrite	
	mm.		mm.
1	55	1.	43
2	58	2	48
3	58	3.	52

On the front and rear faces of the main pretrite cones strong ridges, or crests, run down into the valleys, but where they meet they block the valley but little, inasmuch as they flatten and subside. The first and second valleys are 30 mm. deep below a line spanning the summits of the pretrite cones. On the posttrite side narrower ridges descend into the valleys from the summits of both the main and the secondary cones. Besides these ridges, stronger or feebler welts occupy the sides of the cones.

All around the tooth is a heavy cingulum composed, at the pretrite ends of the valleys, of 5 or 6 tooth-like conules. On the posttrite side the conules are smaller and more numerous. At the front and rear ends the cingulum is more bead-like. At the rear, in front of and above the cingulum, is the talon composed of 3 large conules, of which the inner one has an elongated, the middle one a triangular, the outer one an elliptical base.

In his work on mastodons, Dr. Günther Schlesinger,¹ in an endeavor to show that *Mastodon tapiroides* belongs, not in the bunodont, but in the zyglododont series, calls attention to the crests which descend from the summits of the cones on the posttrite ends of the cross-crests of the zyglododont mastodons. On his page 160 he presents the characters which distinguish *M. tapiroides* from the bunodont type, as represented by *M. angustidens* (= *Gomphotherium leptodon*). On his page 174 he goes on to say that in addition to all those characters there is another which excludes from the bunodont type not only *M. tapiroides*, but all of the zyglododonts. This is the presence of those *cristae*, or crests, which are found on the slopes of the principal and the secondary cones of the posttrite end of the cross-crests. Among the bunodonts he affirms they are never present. The present writer regards this statement as an error. These crests are found especially

¹ *Die Mastodonten*, etc. Denkscr. nat.-hist. Staatsmus. 1. 1921.

well developed on the posttrite ends of the cross-crests of *Gomphotherium* (*Mastodon*) *floridanum*; and distinct traces at least, of these crests are seen in other bunodont species, even in upper molars of *G. leptodon*.

RADIOTELEGRAPHY.—*The present status of radio atmospheric disturbances.*¹ L. W. AUSTIN, Laboratory for Special Radio Transmission Research.²

Our knowledge concerning the atmospheric disturbances is still very meager. The observed facts may be cataloged as follows: (1) In general, atmospherics are stronger at the longer wave lengths. (2) Except for the effects of local storms, they are nearly always stronger in the afternoon and night, while for the higher frequencies this increase in strength is confined usually to the night alone. (3) They are stronger in summer than in winter, (4) in the south than in the north, and (5) on the land than on the ocean. (6) A large proportion of them appear to be directive; that is, to come from definite regions, or centers, as mountain ranges, rain areas, or thunderstorms. It is also reasonably certain that (7) at least most of the long-wave disturbances travel along the earth with a practically vertical wave front,³ like the signals; (8) that a considerable portion are oscillatory in character, though a certain portion are non-oscillatory and give rise to shock oscillations in the antenna at all wave lengths; and (9) that disturbances sometimes occur simultaneously at stations thousands of miles apart.⁴

The origin of the ordinary rumbling disturbances (grinders) has been the subject of many conjectures. Eccles⁵ believed at one time that he had found the source of this type of disturbance, as far as England was concerned, in distant thunderstorms, especially in Western Africa. DeGroot⁶ has suggested that the grinders are due to the bombardment of the upper atmosphere by electrons from the sun or

¹ Presented at the annual meeting of the Section of Terrestrial Magnetism and Electricity of the American Geophysical Union, Washington, D. C., April 30, 1925. Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

² Conducted jointly by the Bureau of Standards and the American Section of the International Union of Scientific Radio Telegraphy.

³ This JOURNAL, 11: 101. 1921.

⁴ M. Baumber, *Jahrb. d. Drahtlosen Telegr.*, 19: 325. 1922. This matter of simultaneous crashes needs further investigation since a certain number of such coincidences may evidently occur by chance.

⁵ *Electrician* (London), 69: 75. 1912.

⁶ *Proc. I. R. E.* 5: 75. 1917.

charged cosmic dust. The idea that this type of disturbance comes in some way from above has also been held by Weagant.⁷ Mosler,⁸ while ascribing the disturbances to thunderstorms, concluded in contradiction to the ideas of Eccles, that thunderstorms could give rise to atmospherics only over a radius of about 60 miles. This limitation in distance was very probably due to insensitive apparatus. A very systematic study of thunderstorms and atmospherics, undertaken by the British Meteorological Office and the Admiralty, has apparently settled the fact that thunderstorms can be located with modern apparatus up to about 1500 miles.⁹

There is still much difference of opinion as to the proportion of atmospherics which is due to thunderstorms. Professor Appleton, at a symposium¹⁰ on atmospheric ionization and radiotelegraphy, November 28, 1924, expressed the opinion that practically all atmospheric disturbances might be produced by thunderstorms somewhere in the world.

It is undoubtedly true that thunderstorms produce many atmospherics, but it is not by any means certain that the lightning flashes themselves are always the actual sources. There is a widely prevailing idea among radio operators that the lightning flash often produces only a harmless click in the telephone receivers. I have made some observations during thunderstorms, using a coupled circuit with rectifying vacuum tube and galvanometer, which indicated that lightning flashes, even within three or four miles, were not as powerful in their effects on the receiving apparatus as many of the disturbances which occurred when no flashes were apparent. This comparatively feeble effect of the flashes is difficult to understand if the current rise at the beginning of the flash is as steep as is often assumed but would be understandable if the lightning discharge curves were of the form and duration of the atmospheric disturbance curves observed by Appleton and Watt (figs. 1-5). On the other hand, it is quite possible that the small deflections from the lightning flashes were due to a paralysis of the detector tube, a phenomenon which often occurs when the tube is exposed to very high electromotive forces. It must, therefore, be concluded that the connection between lightning and atmospherics is still not clear, and valuable work can be done by anyone who will watch the lightning and listen to the atmospheric crashes from thunderstorms in the neighborhood.

⁷ Proc. I. R. E. 7: 207. 1919

⁸ Elektrot. Zeits. 1134. 1912

⁹ World Power, 3: 20. 1925

¹⁰ Proc. Phys. Soc., London, 37: 2D-50D (appendix). 1925.

At the London Physical Society symposium already mentioned, Professor C. T. R. Wilson discussed the probability of there being discharges of thunderclouds to the upper conducting region of the atmosphere. His calculations indicated that thunderclouds of common electric moment might very readily discharge to a conducting layer at a height of 60 or 80 kilometers, since the electric force required to produce discharge decreases even more rapidly with the height than the electric force of the thundercloud. Discharges of this kind, probably non-luminous, may possibly furnish the explanation of the strong atmospherics heard from thunderclouds when no flashes are visible.

Mr. Watson Watt, in analyzing the records of European¹¹ direction-finding stations, concluded that in only about 35 per cent of the cases could thunderstorms be identified as the sources of atmospheric disturbances, though in about 75 per cent of the cases the identified sources were rain areas of some kind.

Captain Bureau¹² of the French Meteorological Office has recently published papers in which he shows that many of the atmospheric disturbances in France are closely connected with the advance of meteorological cold fronts and that the atmospherics are accentuated when these air movements come in contact with mountain ranges.

For the determination of the direction from which atmospheric disturbances come, Mr. Watt¹³ has invented an automatic recording apparatus in which a radio compass coil, tuned to about 30,000 meters, is rotated slowly and continuously by clockwork, the atmospheric crashes being recorded on a drum attached to the coil.

It should be said in this connection that it has been very common in Europe to estimate the strength of atmospherics by the number of disturbances occurring in a given time. This method, of course, would hardly seem to be applicable to our Washington summer conditions, or to the conditions during the disturbance season in the tropics where often in the afternoons and evenings the noise in the telephones forms an almost continuous rumbling through which no signal can be heard unless it is strong enough to rise above the background of disturbing sounds.

† If, indeed, there is a physical difference between the atmospherics, crashes, grinders, etc., it is not at all certain that what is being measured in Europe by the counting method is the same thing that is being measured in America, either by direct estimates of the average dis-

¹¹ *Nature*, 110: 680. 1922.

¹² *C.-R. Acad. Sci.* 178: 556 and 1823. 1924; *L'Onde Electrique* 3: 385. 1924.

¹³ *Proc. Roy. Soc., A*, 102: 460. 1923. *Phil. Mag.* 45: 1010. 1923.

turbance strength, or by measuring the strength of signal which can be read through the disturbances.

On the Atlantic and Pacific coasts of the United States, except for occasional local thunderstorms, very little certain connection has been noticed between the direction of the atmospheric disturbances and rain areas. On the Atlantic Coast, the main disturbances seem to come roughly from the southwest, but it seems uncertain whether the sources are in the Allegheny Mountains or much farther removed, perhaps in Yucatan. Experiments reported by the Navy Department in New Orleans have indicated the more southerly origin.

Unfortunately, very few triangulation experiments have been made in America for fixing the exact positions of sources of atmospherics. In most cases, therefore, the direction is all that is known.

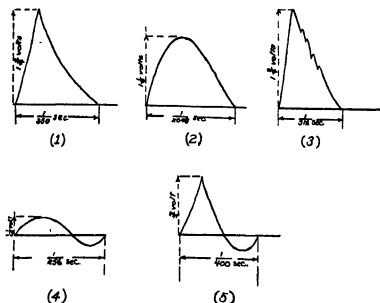
Observations made at Madison, Wisconsin, by Professor Terry of the University of Wisconsin, covering the last two years, show conditions in the Middle West which are similar to those described by the continental European observers; that is, there is no single prevailing direction of the atmospherics, but a more or less definite connection with thunderstorms and other rain areas. This absence of any prevailing southerly source of atmospherics in the central portion of the country casts doubt on the Mexican origin of those observed in the Atlantic Coast region, since the distance from Yucatan to Madison, Wisconsin, is about the same as from Yucatan to Washington.

On the Pacific Coast of the United States it is pretty well established that at least at San Francisco and San Diego the sources of disturbances are largely local, lying in the mountain ranges not far from the coast. These centers seem to be permanently fixed, resulting in very constant directional conditions.

It seems to be pretty well settled, in all parts of the world where observations have been made, that there is a very definite connection between the intensity of the disturbances and the position of the sun. In the northern hemisphere during the winter when the sun is far in the south, the disturbances are generally moderate even as far south as Panama, within 9° of the equator. But as the sun comes north in the spring, there is often a rapid and, sometimes, very sudden increase in strength, and it is reported that stations close to the equator experience two disturbance maxima, corresponding to the two periods when the sun is nearly overhead.

In addition to the study of the sources of the disturbances, the question of their wave form is of much importance. Messrs. Watt and

Appleton¹⁴ in England, working under the Radio Research Board, have made some investigations of this problem, making use of the cathode-ray oscillograph (Braun tube). In their work the atmospheric disturbance, after being received on an aperiodic antenna and amplified by an aperiodic resistance-coupled amplifier, was impressed on one pair of plates of the oscillograph, while a source of 60-cycle current was connected to the other pair of plates for the purpose of drawing out the spot of light into a line on the fluorescent screen. The resulting movement of the spot of light could not be photographed, but could



Figs. 1, 2, 3, 4 and 5. Atmospheric disturbance curves observed by Appleton and Watt

be observed and sketched with some accuracy. Five typical curves are shown in the figures. Most of these appear to be aperiodic, though some are feebly oscillatory.

In figure 3 it is seen that there are minute oscillations superposed on the main curve. It will be noted that the period of the main oscillation is, in all cases, of audio frequency; and Eckersley¹⁵ has pointed out recently that the relatively prolonged impulses of Watt and Appleton can not account for the observed intensity of the atmospherics

¹⁴ Proc. Roy. Soc., A, 108: 84. 1923.

¹⁵ Electrician (London), 93: 150. 1924.

ordinarily experienced in radio reception. He suggests that possibly the ripples, such as are shown in figure 3, may be the actual atmospheric waves. Mr. Watt in the symposium cited accepts this view and adds that more recent experiments in Egypt and elsewhere in the tropics show that there the fine ripple structure is much more common and of much greater amplitude than in England. Professor Appleton, on the other hand, holds that the low-frequency wave forms shown in the figures are capable of producing the observed disturbances at all wave lengths by shock excitation.

In conclusion, the differences of opinion mentioned in this paper show that there is still much to be done before the sources of the disturbances are identified with certainty. While many of the atmospheres undoubtedly come from thunderstorms, many appear to come from regions where no such storms are occurring. It is also believed that even in thunderstorms some of the heaviest disturbances do not come from the lightning itself, but the nature of these non-luminous sources of such great power is still a matter of conjecture.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

923D MEETING

The 923d meeting—the first meeting following the summer intermission—was held in the auditorium of the Cosmos Club on Saturday evening, October 3, 1925. The meeting was called to order by President FLEMING at 8:15 with 33 persons in attendance.

Program: S. P. FERGUSSON. *Meteorology of the total solar eclipse of January 24, 1925.* (Illustrated by lantern slides). The circumstances of the total eclipse of January, 1925 were, in one respect, most favorable for the study of the very small, temporary disturbance of the atmosphere caused by the shadow. The path crossed a region abounding in easily-accessible sites for observing-stations and instruments capable of indicating the small changes of condition to be expected were available at several observatories in and near the path. On the unfavorable side, even near the coast of Connecticut and Rhode Island, totality occurred only two hours after sunrise, the altitude of the sun was below 20° , and the probabilities were that the effects would be small, at best, and negligible west of the 75th meridian. Furthermore, in January, in this region, the variability of the weather and its storminess attains the annual maximum—conditions likely to obscure the small effect probable.

Through the courtesy of W. G. FOYE of Wesleyan University, in providing facilities for the exposure of instruments during the eclipse, the author obtained continuous records of atmospheric pressure and the direction of the

wind, observations of the kind, direction, velocity, position, and density of clouds and attempted the measurement of shadow-bands. The wide scales of the automatic instruments permitted readings of pressure to 0.03 millibar and of the direction of the wind to 2° of azimuth, at intervals of two minutes. The observations of clouds were made at irregular intervals, usually of three to seven minutes. To these data have been added observations of temperature with an Assmann psychrometer at Wesleyan, records from Draper anemoscopes at Central Park, New York, and Blue Hill Observatory, Massachusetts, and observations of temperature and wind at New London, Connecticut, and Westerly, Rhode Island, for which, respectively, the author is indebted to W. I. MILHAM, J. H. SCARR, ALEXANDER McADIE and C. F. BROOKS.

The weather on the day of the eclipse was unusually favorable for all observations, but very uncomfortable; a severe cold wave prevailed and the temperature ranged between -25° and -15°C . The data referred to have been compared with normals or averages of each element (1) for all conditions at the time of year and (2) for the conditions prevailing on the day of the eclipse. The more important results may be summarized as follows: The fall of temperature of 1°C . (slightly more than one half that occurring during average conditions) did not begin until within 30 minutes of totality and the rate of fall at first was very slow; the lowest temperature occurred about ten minutes after totality.

The change of pressure was so small that it may be submerged in irregular fluctuations, of which many occurred during the 12 hours preceding the eclipse. It is possible, however, that the fall of only 0.4 millibar beginning 30 minutes after totality was caused by the shadow, for, under the conditions prevailing, retardation of all effects is to be expected.

At stations in Connecticut the usual calm and irregular changes of the wind occurred during totality, followed by an increase of velocity and a reversal of the direction after totality, indicating a tendency to blow toward the region of lowest temperature and pressure. Similar tendencies were noticeable in the record at New York, but at Blue Hill the velocity was too high and too variable for the detection of the very small eclipse-effect.

A slight decrease in the amount of the alto-cumulus clouds is believed by some observers to be due to the shadow. There was a fall followed by a decided increase in the velocity of the clouds, and the changes of direction indicated a tendency of the air at their level (estimated at 2000 metres above sea-level) to move toward the region of lowest pressure; these results confirm the first observations of this effect during the eclipse of May, 1918.

The shadow-bands, on first appearance, were a mass of fine, bright lines in rapid irregular motion lengthwise as well as laterally; on second appearance the bands were more definitely outlined, but in both instances precise measurements were impossible. There was a general movement, nearly parallel to the path of the shadow, at a rate of between one and two meters a second.

Observations, accumulated mostly since 1900, indicate that these bands probably occur chiefly, perhaps only, during the mixing of masses of air having different densities or temperatures, the necessary contrasts of density being maintained to an appreciable degree only during the rapid decrease and increase of temperature immediately before and following totality. The general movement or drift of the bands appears to be more closely related to that of the eclipse-wind than to the natural wind prevailing at any level. (*Author's abstract.*)

Discussion. The paper was discussed by Messrs. PAWLING, CURTIS, HUMPHREYS, and PRIEST.

C. MOON: *A method of comparing the relative frequencies of a tuning fork and a pendulum.* (Illustrated by lantern slides.) An experimental arrangement was described for measuring the relative frequencies of a tuning fork and a pendulum by the well-known method of coincidences. The frequency of the fork must be very near an exact multiple of that of the pendulum.

A series of flashes of twice the frequency of the fork is obtained by the device used by CURTIS and DUNCAN. The light from the slit in the vanes carried by the prongs of the fork is reflected directly into a telescope by two mirrors placed side by side, one attached directly to the pendulum and the other to the pendulum support. The flash images of the slit from the fixed mirror appear superposed at the same place in the telescopic field, those from the moving mirror being separated into a series of lines which appear in the field at each forward and backward swing of the pendulum. For convenience a crude auxiliary pendulum is used to intercept the light source during the backward swing of the pendulum, so that only one series of images are seen for each complete oscillation of the standard pendulum. If the fork frequency is an exact multiple, say N times that of the pendulum, then the image of the first flash, the $(2N + 1)$ th, the $(4N + 1)$ th . . . etc., will always appear at the same place in the telescopic field. Since the multiple relation will not be exactly fulfilled, there will be a slight progression of successive images and at regular intervals coincidences will occur between one of the lines from the moving mirror and the line from the fixed mirror.

The time interval between two successive coincidences can be measured with a stop watch. It represents the time required for the fork to gain or lose one-half of a vibration on the pendulum. This interval known, the relative frequencies can be readily computed.

The method has been applied to a 100-cycle fork driven by a vacuum tube and a standard Coast Survey gravity pendulum. With the fork adjusted so that coincidences occurred at about 20 second intervals, the time of a single coincidence may be measured with an error of 5 per cent. This causes an error of approximately one part in 100,000 in the relative frequencies. By measuring five consecutive coincidences, the error can be reduced to two parts per million. (*Author's abstract.*)

Discussion. The paper was discussed by Messrs. SWICK, HUMPHREYS, CURTIS, HEYL and PRIEST.

924TH MEETING

The 924th meeting was held in the auditorium of the Cosmos Club on Saturday evening, October 17, 1925. The meeting was called to order by President FLEMING at 8:16 with 55 persons in attendance.

Program: L. B. TUCKERMAN. *We see things which are not there.* (Illustrated by lantern slides.)

If the carbon copy of a typewritten sheet is placed in register over the original and then rotated slightly, a series of concentric circles is seen. When the carbon copy is displaced vertically the circles shift horizontally, the center of the circles always lying at the point of coincidence of the two copies. This effect must have been seen many times, but only one stenographer was found who has recognized the character of the pattern seen. Similar results are obtained from any irregular pattern. An example is a doubly printed photograph, the negative being slightly rotated between the two exposures. An-

other example is a trail photograph of circumpolar stars. The phenomenon is familiar to astronomers who match star photographs in detecting comets or asteroids or in determining proper motion of stars. The illusion is caused by the fact that in looking at objects we mentally complete the patterns which are suggested by the geometrical arrangement presented. A multitude of similar illusions are known and are effectively used by artists. (*Author's abstract.*)

Discussion. The paper was discussed by Messrs. HEYL, STIMSON, STOKLEY, PRIEST and FERGUSON.

PHILIP P. QUAYLE: *Single spark photography and its application to some problems in ballistics.* (Illustrated by lantern slides.) An apparatus was described for obtaining shadow pictures of objects in rapid motion by a properly timed illuminating spark. The general principle involved is not new but the means for carrying it out are believed to be unique and considerably more effective than any hitherto described. The apparatus is so arranged that the illuminating spark occurs when the object to be photographed is between it and the photographic plate. There results an ordinary shadow of opaque objects, such as bullets, and inhomogeneities due to sound waves and turbulence of the air give distinctive patterns owing to refraction effects. In the illustrative photographs presented are to be found some striking sound wave phenomena.

The photographs were presented primarily to illustrate the usefulness of the method but they give interesting and important information concerning the gas leakage in a revolver, the acceleration of projectiles outside the muzzle, the so-called stringing effect in shot shells and many other phenomena attending the discharge of firearms. Other characteristics of the photographs were pointed out and in part explained. (*Author's abstract.*)

Discussion. The paper was discussed by Messrs. HEYL, LAPORTE, HAWKESWORTH, BREIT, TUCKERMAN, WRIGHT and others.

925TH MEETING

The 925th meeting was held in the auditorium of the Cosmos Club on Saturday evening, October 31, 1925. The meeting was called to order by President FLEMING at 8.17 with 33 persons in attendance.

Program: N. E. DORSEY: *A thunderbolt and its results.* (Illustrated by lantern slides.) The nature of the damage which was done when lightning struck a tulip tree was described, and the more interesting features were illustrated by lantern slides. The tree was an interior one of a small, isolated group surrounding the frame church at Annapolis Junction, Md. In the group were several others of the same kind and of the same height (47 feet) as that struck. The most exposed of the tulip trees is about 55 feet high, and the tower of the church is 56 feet high and only 30 feet from the tree which was struck. Neither of these were damaged in the least. Furthermore, the tree was struck within nine feet of the ground. A segment on the northwest side of the tree was splintered, and sections were torn from it; the larger, unsplintered portion of the trunk was split and bowed apart; the blazed area extended only to a height of 27 feet, and the split extended only a short distance higher. Above that, the trunk was undamaged; the lower thirty inches of the trunk was not split. On a large section torn from the tree was a limb of which the overgrown portion had been broken squarely across the grain, and had been pulled from the trunk as a tenon might be pulled from a mortise. This break could have been produced only by a longitudinal pull. Along the

western edge of the splintered segment, and, as nearly as could be determined, in the plane bounding the splintered segment, were four small isolated holes burned through the bark. The hole next to the top extended into the wood for about two inches; and for most of its length it was about the size of the lead of a pencil. The topmost and largest hole was eight feet from the ground; the wood around it was badly torn, and much of it was lost. These four holes mark the spots in which the tree was struck; they pass straight through the sap-wood, which was not seriously damaged. The plane defined by them passes between, and close to, two trees exactly similar to the one struck. Everything indicates that the path of the stroke was essentially uninfluenced by the local field near the ground. The stroke appears to have been of the nature of a free electrical charge travelling, under its own momentum, along a line determined by conditions in the clouds. It was suggested that such a stroke may be closely akin to, and perhaps may actually be, an intense, concentrated beam of cathode rays. It was pointed out that the production of such a beam is not inconsistent with what we know of the conditions in a thundercloud and it was shown that such a suggestion serves to correlate in a logical manner all the prominent effects observed. That the suggestion involves assumptions of which the validity can not at present be demonstrated, was admitted. (*Author's abstract.*)

Discussion. The paper was discussed by Messrs. WHITE, HUMPHREYS, PAWLING, BOWIE, and others.

ROBERT H. GAULT: *Touch as a substitute for hearing in the interpretation and control of speech.* (Illustrated by a chart.) This is a report of psychological experiments that are being conducted in Washington under the auspices of the National Research Council. The problem is to determine (1) whether tactual sensation can be made a sufficiently fine means of discrimination to enable one to distinguish the forms of speech and to interpret them, and (2) whether tactual sensation can be successfully employed as sufficient cues to aid in the control of speech—particularly the speech of semi-mutes.

The author employs for his purpose a telephone-like instrument and an amplifier. Each observer (fifteen approximately totally deaf persons) holds a receiver of the instrument in his hand. As many as six sit as observers simultaneously. Each one can feel the words of the experimenter upon the palm of his hand or upon a finger tip, depending upon how the receiver is held. Theoretically no two words feel alike and no two sentences feel alike.

Charts are presented showing the progress of learning sentences, vowel qualities and isolated words. The most successful subjects, working from October 8, 1924, to November 25, 1924, became able to identify, with over 90 per cent of complete accuracy, ten sentences of six monosyllabic words each. They practiced but 25 minutes daily, five days each week. Subsequently the same subjects in the course of three weeks attained a like degree of accuracy in identifying the long vowels. From June 11 to July 8, 1925, four observers, practicing three half-hour periods daily, five days weekly, attained a fair degree of accuracy in identifying 58 words.

In the course of this period selections from the 58 words were employed from day to day to form new sentences that had never before been felt as sentences. The subjects were given an opportunity to interpret the sentences by their feel if they could. One hundred and seventeen such sentences were used in this manner. From the four subjects there were 468 reports; 225 of these were correct word for word; 131 more were correct in sense.

During the summer period referred to, 103 groups of homophonous words

(words that are alike from a lip-reader's point of view, such as "aim, ape") were chosen as stimuli to determine how nicely those of a group could be distinguished by touch. There were groups of two words, three words, etc., up to ten. The members of each group are supposed to *look alike*. As a matter of fact in many instances the members of a group can be distinguished by vision in our experimental situation. Only 50 of the 131 groups are made up of truly homophonous words according to the author's findings. Among the 131 groups there are but seven in which the subjects distinguished better by lip-reading than by touch. In one instance the two methods produced a tie. Ordinarily touch proved to be by far superior to lip-reading in relation to these groups of words.

The author applied the tactual method to the improvement of the voice of a semi-mute. He was made to feel the experimenter's voice upon his hand; thereupon he undertook to reproduce the *feel* by applying his own voice to a transmitter that duplicated the one operated by the experimenter. Thus the subject improved the pitch and syllabication of his words. It was found possible to employ several subjects simultaneously in this experiment. In that situation members of the group criticised their companion who was trying to copy the experimenter's voice. This practice stimulated interest, and furthermore, the subject with the receiver was aided thereby to discover the tactual criteria for vocal control. (*Author's abstract.*)

Discussion. The paper was discussed by Messrs. HAWKESWORTH, HUMPHREYS, GIBSON, BOWIE, MERWIN and others. President FLEMING on behalf of the Society thanked Professor GAULT for his interesting paper.

On request by the President, Major BOWIE presented an informal report on the computations of the gravity observations done under a grant from the Society. Five stations in the Southern Pacific were completed and the results will appear in an early issue of the JOURNAL.¹

926TH MEETING

The 926th meeting was held in the auditorium of the Cosmos Club on Saturday evening, November 14, 1925. The meeting was called to order by President FLEMING at 8:19 with 55 persons in attendance.

Program: L. V. JUDSON: *Geodetic instruments from the viewpoint of the physicist.* (Illustrated by lantern slides.) The instruments particularly referred to are the base line tapes and apparatus for their test; also theodolites and instruments for testing their angular graduations. The design of apparatus used for testing base lines shows striking differences in the different countries. The apparatus used at the Bureau of Standards for testing base-line tapes is both simple and accurate.

The need of extensive investigations in the field of precise graduations of circles was emphasized, and a view of an apparatus for this purpose was shown. It was pointed out that the modern geodetic instrument must embody all the improvements which the physicist can apply, and that fundamental investigations were necessary as a preliminary to advances in design.

As an example of the investigation of 50-meter invar base line tapes which is being carried on at the Bureau of Standards the question of the effect of concentrated loads upon the distance between the terminal graduations of the tape was taken up in some detail. (*Author's abstract.*)

Discussion. The paper was discussed by Messrs. BOWIE and HODGSON. W. L. HUMPHREYS: *An unusual display of mammo-cumulus.* (Illustrated

¹ See this JOURNAL 16: 445-450. 1925

by lantern slides.) The mammato-cumulus cloud, also called pocky-cloud, festoon-cloud, sack-cloud, and other more or less descriptive names, is a sheet of cloud with numerous, thick-set, hemispherical pendants. This peculiar feature appears to be the result of an overflowing sheet of potentially cold air, dropping down slightly at numerous places and forming cloud as it goes. This phenomenon is most frequent in connection with thunderstorms, and sometimes is well developed in association with a tornado.

Two pictures were shown of an exceptionally fine example of the mammato-cumulus, obtained at Ashland, Ky., on the afternoon of July 3, 1925, just preceding a heavy but not intense local thunderstorm. (*Author's abstract.*)

Discussion. The paper was discussed by Major BOWIE.

PAUL R. HEYL: *Perpetual motion in the Twentieth Century.* Prior to the recognition of the principle of the conservation of energy it was believed that perpetual motion was impossible, but every proposed device of this character had to be examined on its own merits, and the special reason for its failure to work pointed out. The establishment of the principle of the conservation of energy made this unnecessary; all such devices could be dismissed as violating this general principle.

Very soon the question was raised as to whether there could not be a perpetual motion of a second kind; that is, whether it was not possible under some circumstances for heat to run up hill. MAXWELL showed in the early seventies that the second law of thermodynamics could be set aside by the interposition of intelligence, BOLTZMANN and PLANCK later showed that the basis of the second law was one of probability merely, and that actual departures from this law on a microscopic scale must be expected to occur continually and spontaneously.

In 1900 LIPPMANN suggested two perpetual motion devices based on this principle, and in 1907 SVEDBERG proposed others. In 1912 SMOLUCHOWSKI pointed out a general principle which, as he supposed, rendered these devices inoperative. The speaker showed that SMOLUCHOWSKI was in error in the application of this principle and that the devices of LIPPMANN and of SVEDBERG must be regarded as valid on a molecular scale. (*Author's abstract.*)

Discussion. The paper was discussed by Messrs. DRYDEN, HAWKESWORTH, BREIT, ADAMS, TUCKERMAN and others.

H. A. MARMER, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The Petrologists' Club met at the home of F. E. Wright on January 5. H. S. WASHINGTON described the methods now being used in Italy to obtain potassium salts, alum, and pure silica from leucite which is extracted mechanically from certain leucitic lavas in the central Italian volcanic region. There was also a general discussion, led by W. T. SCHALLER and C. S. ROSS, on *What is a magma?* From the discussion it appears that current usage of the word is not uniform, the stress being laid by different writers upon such different qualities as (1) high temperature, (2) liquidity, (3) location in a reservoir, (4) action as a source of lava or ore-bearing solutions, (5) possession of dissolved water in various percentages.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 16

FEBRUARY 4, 1926

No. 3

ENTOMOLOGY.—*Entomological taxonomy: its aims and failures.*¹

1. FROM A TAXONOMIC VIEWPOINT. S. A. ROHWER, Bureau of
Entomology

When the idea of this symposium occurred to the chairman of the Communication Committee, it is very probable that he had recently seen some paper of a "taxonomic" nature which seemed to be lacking in a number of desired features. Otherwise the symposium would probably have been given a different subtitle, for I doubt very much the propriety of the use of the word "failures." The strongest idea it was intended to convey was "shortcomings." Be that as it may, we have accepted the subject for discussion and I think it is one we may well discuss. The science of Biology has made remarkable strides in the last twenty years. It has had opened before it many lines of investigation which were heretofore unknown.

Some of these new studies have gained such popularity that their patrons have thought so well of themselves and the importance of their investigations that they have coined new "ologies" to separate themselves from the other workers. All this time taxonomy has continued and has attracted the attention of only a few. More recently, however, the pendulum has swung back and today the classifier is held in more esteem. The time seems to be passing when it will be necessary to apologize for the fact that one is a taxonomist. This returning into the good graces will not last long unless the students of taxonomy avail themselves of the materials which have been gathered by investigators in related fields, for taxonomy can not be a deaf and dumb science and still live. For this reason it seems desirable to discuss the aims of taxonomy, and as we consider these perhaps we may in our reflection see some shortcomings.

¹ Papers presented at the 373d meeting of the Entomological Society of Washington, held March 5, 1925.

Before getting too far into the subject it will be well to accept, at least for the moment, a definition of taxonomy; and while we may not all agree, I venture the following for consideration. Taxonomy consists of the grouping of organisms in a phylogenetic manner after a consideration of all of their characters and characteristics.

Accepting such a broad definition, the taxonomist must base his classification not only on external morphology but he must also call to his aid anatomy, physiology, embryology, cytology, ecology, paleontology, and distribution; in fact, he must consider his organism not by itself alone, but he must understand its function and its place in relation to other organisms past and present. To do all this is no small task, and to say that, is not all. If in entomology we were dealing with a limited number of forms and if these forms had such habits as to permit a detailed study of them, the task would be of sufficient magnitude. But when we consider that conservatively estimated there are about 640,920 described insects, and that this represents perhaps less than one-tenth of the forms which actually exist, and that for most of these 640,920 forms, we know only a few cabinet specimens of adults and nothing concerning their habits, the task becomes stupendous. It is very probable that this very fact has caused the taxonomist to become so deeply involved in the details that he has lost sight of other allied "ologies," and thus received such criticisms as "Oh! he is only a narrow taxonomist." But let us not stop with these apologies. We grant the magnitude of the task and we admit also that some very good results have apparently been obtained by a careful comparison of morphology. If good results have been accomplished by a study of parts, how much better the results will be if we consider the whole.

But let us go back and consider briefly some of the various lines of investigation a taxonomist should be familiar with and include in his consideration when making a phylogenetic grouping. I imagined I saw a shaking of the head when I suggested paleontology—I hope not. Yet most taxonomic entomologists ignore the fossils. So much are they forgotten that many times they are not cataloged. Such an attitude can not be defended by any scientific excuse. Where would be the classifications and the fundamental results derived from them in mammalogy had the fossils been thrown aside because there were too many recent things to describe?

When I used the word "anatomy" a short while ago I meant to restrict the use of the word somewhat, and had in mind more a consideration of the internal softer organs. So little is known concerning

these in insects that not much can be said, yet when more is known and their function better understood, I venture the suggestion that the taxonomist will find valuable evidence to refute or uphold his major groupings. Of embryology and cytology little can be said, yet both of these lines of investigation will furnish valuable aids to a true phylogenetic arrangement. Distribution if studied carefully will often prove of great aid. When I hear discussions of so-called discontinuous distribution, the first thought that comes to my mind is, how about the true relationships? Perhaps many of the examples of discontinuous distribution are due to faulty taxonomy. If there is anything in this thought then a study of distribution may help the taxonomist to see some of the weak points of his classification; hence it is a line of study the taxonomist should consider. And there is also the converse, for a study of distribution may just as well tend to show relationships.

In including ecology in the list of fields from which the taxonomist must expect aid, I have ventured to use a comprehensive definition of the word "ecology," and I have therefore included under this head the information usually listed by taxonomists under such headings as "host," "habitat," and "habits." Taxonomists have long paid considerable attention to the host and host plants, and to a lesser extent have they considered the habitat and habits. The consideration of these points is of importance, and when we get the phylogenetic point of view it becomes more so. We cannot logically expect that groups which have complex host relationships and specialized habits will give rise to groups with simple host relationships and generalized habits. Such may be the case. Cases of reversion are known, but a classification which indicated that this was true might well be carefully and critically examined before it is pronounced as having been made along phylogenetic lines.

We have considered only very briefly some of the points but before my time is completely gone, I want to include a word about nomenclature, the bug-bear of most taxonomists. I said "most" and I believe advisedly because there are some who have in my opinion so completely forgotten the true significance of nomenclature as to be in the position of trying to put the cart before the horse. My appreciation for the standardization of names, the application of general rules and suggestions on procedure is very great. In fact I fully appreciate nomenclature, so much so that I have been guilty of doing nomenclatorial things. But I have not as yet forgotten, and I trust I never shall forget, that nomenclature, as we entomologists use the word, is only a

handmaid to zoology. Nomenclature deals with names, not animals. I venture the guess that less than ten per cent of the changes in the names of insects are due to nomenclature. Most of them are due to a change in the conceptions of groups. In other words, they are made for zoological reasons. It must be so. The classification of insects must change. New facts are before us every day. We apply these in our taxonomic work and we change the name of some little insect or other. Such a change is not due to nomenclature. But I have almost forgotten why I brought up this handmaid to taxonomy. No taxonomist likes to change names but no taxonomic work, however sound from a phylogenetic point of view, can stand for a long period of usefulness unless its author carefully considers the nomenclature of the group. It is essential that entomologists agree on names, and if all taxonomic workers hasten to establish the landmarks by which group names may be recognized, fewer changes will be necessary and their work will be of a more permanent nature. The establishment of genotypes for all genera and especially those on which supergeneric names are founded is important, and to a very large extent this must be done by the taxonomist.

In our definition we said taxonomy was the grouping of organisms and this presupposes there are organisms to be grouped. So a study of taxonomy must first await the accumulation of materials. A taxonomist without a collection is as bad off as the man at sea without water and the one with a small collection is perhaps, as far as real progress is concerned, worse off. If proper taxonomic work can be done only when all factors are considered then to work in a taxonomic way over only an incomplete assemblage of specimens can not produce good results. In almost every group in insects we have examples of poorly constructed classifications because of an examination of an inadequate number of specimens. We must not discourage the collecting instinct in the taxonomist. On the other hand we should lend him all encouragement. We should place at his disposal for study all the material of his group. He should have material from all regions and in sufficient abundance for him to study the variation of individuals.

This need for collections imposes an obligation on the taxonomist as well as those who foster his work. It makes it necessary for him to care for these collections; they must be arranged in a careful, orderly manner; they must be labelled. The taxonomist must leave to his science and posterity evidence from which he made his conclusions. There must be no doubt about the fact that certain specimens were seen. The taxonomist has therefore devised a method by which his

co-workers and successors can know what he was talking about. He calls certain specimens types. But this is not enough; he forms conceptions about other workers' groups and he must leave evidences of the limits of his conception. Here many workers are negligent. They do not tell us definitely about these. The aim of all taxonomists should be to leave the evidences of their work in such good order as to leave no doubt in the minds of other workers on what their conclusions were founded. In short the taxonomist should care for his collections and arrange and label them so as to aid, not hinder, other investigators. I am sure all of you could cite many shortcomings here.

Another aim of taxonomists is large libraries. The taxonomist must know what others have done. In a field as vast as entomology this is of the greatest importance. It is impossible for one worker to know all. It is imperative that he know what has been done before. Large libraries must also be considered a necessary aid to taxonomic work. But libraries are of but little use unless one knows what is in them and where to find it, so indices are necessary. In view of the rapidity with which work is being published, these indices must be up to date to be of real service. While in a certain sense one can hardly say these libraries and indices are aims to taxonomic entomology, we must admit they are aims of taxonomic entomologists, and you all will agree it would fill a large volume to list the shortcomings because of their lack.

Summing up briefly, the aim of taxonomic entomology should be the phylogenetic classification of insects based on all available evidence, such evidence to include a consideration of anatomy, morphology, embryology, cytology, physiology, paleontology, ecology and distribution. If such are the aims of taxonomy then we have only to examine our literature to see how completely we have met them. Such a consideration of the literature would probably make many feel that there had been many shortcomings. Of course there have. But many of them are due to the magnitude of the task and some of them are due to the changing viewpoint.

I hope the viewpoint may continue to change, that taxonomists will continue to include in their papers more and more information concerning all the characters and characteristics of the insects they treat. Many taxonomists have much of this information at their command and use it consciously or unconsciously in forming their classifications. Let us urge them to include more of it in their papers so they may be storehouses of information to other workers. By doing so their usefulness will greatly increase and they will rise in the esteem of workers in allied fields.

2. FROM AN ECONOMIC VIEWPOINT. A. C. BAKER, Bureau of Entomology

I have been asked to discuss the relation of taxonomic entomology to economic entomology and the failures of the former in this relationship. Such a request in itself indicates the failure I shall mention. Perhaps, however, it is not a failure. Perhaps it is merely a circumstance incident to growth.

Lest I be misunderstood I wish to distinguish clearly between the science of insect life and those practices in the art of agriculture which concern themselves with insects and with which entomologists as agricultural advisors have much to do. This dual function of the entomologist, as advisor and as discoverer, has confused certain practices of the art with the science that underlies them. I presume that I am not expected to discuss the relation of taxonomic entomology to the art of agriculture.

Since this symposium is on taxonomy it may be well at the outset to delimit the different fields that are often confused with taxonomy by reason of the fact that taxonomists work in them. We must distinguish taxonomy, classification, and nomenclature. Taxonomy, as its name implies, is not concerned with the arrangement as such but with the reasons and causes back of that arrangement, with the underlying principles. Classification, on the other hand, constitutes the arrangement itself. Thus the same taxonomy may be employed in a classification of a family of Hemiptera or in that of a family of Hymenoptera. Nomenclature, again, is a subject which is concerned with the correct names for the units in a classification. It deals neither with the methods back of the classification nor with the classification itself. Thus we have nomenclature as a result of classification and classification as a result of taxonomy. In this relationship taxonomy is basic.

As I see it, there are three types of taxonomic entomology today, and these three types recapitulate the three stages in its growth.

The first is the accumulative type. Here the main interest centers on the collection. The aim is to complete the series, to amass material. Species are described. These are carefully placed away, perhaps according to some accepted classification, and other species are described. Of this type I shall have little to say for the reason that it concerns itself very little with taxonomy as I understand it. In many cases even the classification is already a fixed conception. The author merely adds to the nomenclature of that classification in the naming

of species not already included. In regard to this type, however, I shall say one thing. It might be of enormous advantage. As it stands today its devotees are interested in individual groups. They pick these from the population and ignore the others. But in a study of the accumulative type the interest should lie in the equilibrium of the population. It is better to know the workings of a field than the disconnected items of a world.

The second type is the morphological one. Here the main interest centers on structure. Dissection is not uncommon and an attempt is made to reconstruct the relationships by means of the structures studied. Phylogenetic trees therefore are the mode and theoretical discussions are common. There may even develop a voluminous literature on the interpretation that should be placed on the veins of the wings or the spines of the legs. Most taxonomic entomology today is of this type. Perhaps it is so of necessity. While I realize the valuable contributions that have been made from this viewpoint and the great handicaps under which brilliant men have labored in this field, I can not help feeling that this type of taxonomy has one decided fault. The structure is the primary concept and in concentration upon it the entomologist is apt to lose sight of his real goal. The broader visioned taxonomists of the morphological school, however, are alive to this danger. Hence they constantly discuss and write about the suitability of characters. They talk of natural characters and of artificial characters, but they do not tell us how one character can be more natural or more artificial than another.

The third type is the biotic one. Here the main interest centers on the insect alive rather than on its dead body. The taxonomic laboratory is no longer an orderly array of dead insects. It is a dynamic world of living things. In its fullest realization this type requires some departure from the usually accepted ideas. Side by side with the collection will be, not only the morphological laboratory, but the insectary where the insects may be studied alive. And beyond all this there will be the outdoors. The taxonomist will once again become the naturalist, but with this difference he will have at his command a great store of modern technical methods.

The biotic type of taxonomy will not only change the work, the publications too will change. They will be appreciated. A monograph of a genus will no longer lie uncut upon the shelf. It will become a live book full of interest for the biologist, the agriculturist and the physician. It will be used and its author will receive the credit he deserves.

TABLE 1.—CLASSIFICATION OF SUBFAMILY ERIOSOMATINAE

Forming galls or pseudo-galls on trees and migrating to trees or herbs, usually to the roots

GENUS	PRIMARY PHASE	SECONDARY PHASE	GENUS	PRIMARY PHASE	SECONDARY PHASE
Pistacia Association—Tribe Fordini					
Forda					

Most work today is associated with the evolutionary viewpoint. As taxonomists, however, we have conceived of morphologic evolution. We have concentrated upon supposed species. But if there is an evolution it is the entire environmental complex that evolves. Things change only in relation to other things. Perhaps I can make myself clear by saying that taxonomy should concern itself with events more, with supposed things less, with the quantitative record of conditions all the time. Our enthronement of type specimens is an admission of the failure of our taxonomic method.

I may be pardoned if I refer to the group on which I have worked the most, the aphids. My excuse is that I know this group the best. Five years ago I presented a classification of this family. That classification was woefully inadequate. In order to illustrate the taxonomy employed, however, I am showing a tabulation of one subfamily, the Eriosomatinae (Table 1). It will be noted that an attempt was first made to determine something of the living insects. Host relation was selected by reason of the fact that the insects are peculiarly phytophagous. The selection thus of one factor is admittedly weak. For as it is, the total association evolves so that it is the assemblage of factors that must picture the events. One factor however appears at times to be almost a master one and to reflect the others. On this possibility we have chosen host relation in this subfamily. The primary phase of the life cycle was accepted as fundamental for reasons that are obvious.

It will be noted that certain associations at once become evident, such as the Elm Association, the Poplar Association, and the Pistacia Association. The insects falling in these associations were again segregated, using type species and the habits of type species as a basis. The list of genera falling in the Elm Association reveals certain morphological characters common to all species and peculiar to the genera in this Association. These characters therefore distinguish the tribe. A similar examination of the forms in the Poplar Association shows other characters peculiar to these genera and common to them. The correct diagnosis of the tribe Pemphigini therefore becomes evident. And so the examination proceeds throughout all of the associations. In the end we have tribal descriptions which reflect not only structures common to the insects falling therein, but life habits which are equally common to them—a classification of the animals alive.

It will be urged by some that taxonomic studies of this kind deal altogether with secondary things, that structure is basic. But if we

accept evolution surely it is activity that is basic. Unrelated forms may of course show similar habits but such forms would segregate earlier on other biotic factors.

But aside from this question the economic value of the taxonomy employed will be clear if we look for a moment at the Tribe Fordini. Species of the genus *Forda* are common in this country on the roots of plants and in ants' nests. Considerable study has been given to the species, and occasional revisions or partial revisions have been published. But these revisions left us in much the same state as we were before, for the reason that the investigators worked from the morphological viewpoint. More supposed species were described, but this only meant, at bottom, a more complete catalogue of our ignorance, for the work was all done on the incomplete secondary phases of the life cycles. The workers did not conceive of the Pistacia Association. Had they done so they would have realized that the key to the genus on this continent lay only in Texas and southward, and that years might be spent on the secondary northern remnants of these Pistacia forms without any real advance in knowledge.

A similar picture of this very kind is the history of the study of the woolly apple aphid, *Eriosoma lanigerum*. For a hundred years men tried to solve the life history of this economic insect. Medals and prizes were offered for its solution. Years of research and large sums of money were spent without result.

A glance at the biotic arrangement on the screen will show how simple the solution becomes; and it is equally simple in other instances. When we find another species of *Eriosoma* as a pest on pear roots we turn at once to the elms. When we find still another very injurious to the roots of gooseberries we turn once more to the elms. Still another species is abundant on the roots of service berry and once again we take our way to the elms.

Another example may be given. When a *Pemphigus* is discovered as a pest of the beet fields we can turn at once to the poplars for its complete cycle. In another region the poplar segregated does not exist but the beets are nevertheless attacked. So we find a different poplar with a different *Pemphigus* migrating to the beets as before. Still another species is a pest of crucifers, and turning to the poplars we can determine its identity and the economic factors involved.

Time will not permit me to follow the argument further, but I shall give one word in regard to the reception this work has had. My paper in 1920 did not give completely my taxonomy. For obvious

reasons I contented myself with a classification—with tabulating and discussing the characters resulting from the taxonomic study. Nevertheless a thorough student might discover the method in the background. Such a student is Professor Albert Tullgren of Sweden. In 1925 he referred to my classification in the following words:

"One of the most important and in parts most interesting systematic work on aphids that has been published in the last ten years is A. C. Baker's *Generic Classification of the Hemipterous family Aphididae*. Baker presents, often in a very alluring manner an entirely new system for the Aphididae and bases it on reasoning which often has a very convincing effect. He divides the entire family into 4 sub-families, Aphidinae, Mindarinae, Eriosomatinae and Hormaphidinae which are among themselves almost equal although the Aphidinae and the other three subfamilies are derived from two different origins of the hypothetical stem. The reasons given for this separation into 4 subfamilies do not appear to me, however, to be entirely free of criticism and I deem it therefore more cautious for the present to consider the three last groups as one subfamily."

And again he says:

"Baker divided his subfamily Eriosomatinae into five different groups, Eriosomatini, Pemphigini, Malaphuni, Prociphilini and Fordini. If one studies closely the characteristics of differentiation one finds that he derived the same first of all from the biological differences of the generic elements. And one can not help thinking that he put a higher value on these characteristics than on the morphological ones. For this reason presumably he has arrived at the peculiar conclusion, according to my opinion, that the Pemphigini and the Prociphilini represent two different branches of the stem which are about equal to the Eriosomatini."

I have cited Tullgren because I know him to be a scholar. Perhaps he is right. I foresee the day, however, when the taxonomist will not be set apart from the economic entomologist, when the collector will concentrate on true samples of the population, when the morphologist will consider function as important as form, and when all life history studies will be made by taxonomists of the biotic school. When that day comes there will be only one type of entomology. It will be economic. Its aim will be to understand and to express with mathematical exactness the laws and principles underlying the elements, the contacts and the inter-relations of the insect world. We are fast approaching the saturation point of our population and the day may not be far distant when we shall be pressed for that understanding.

3. FROM AN EDUCATIONAL VIEWPOINT. E. D. BALL, Department of Agriculture

Taxonomy in its highest development, as I conceive it, is an explanation of the actual relationship of existing forms of life to each other. Although of necessity expressed in a linear series it should be an arrangement of the existing branches of the tree of life into groups according to their derivation and into a series showing inter-relationship of the groups. In the major branches of both botany and zoology, taxonomy has already approached this idea. When it comes to the lesser divisions and more obscure relationships it is still far from certain of its foundations and is undergoing a gradual evolution as new discoveries in fossil forms are made and new interpretations of relationships in living species are established. Taxonomy, then, in its ideals is an interpretation of evolution, one of the most profoundly interesting and profitable fields of biological research.

Taxonomy in its lowest expression is merely an enumeration of a group of individuals. Enumerating individuals for taxing purposes was man's earliest effort and from this the science received its name. Some taxonomy has not materially advanced above this level. Let us illustrate: It would be possible to classify an indefinite number of wooden blocks of different shapes so that each one of a given group would fall into a definite category. The primary division might easily be (A) long blocks; (AA) short blocks; and (B and BB) under each one might be blocks with right angles and blocks without right angles, and so on indefinitely, and when you finished your task you would have a classification for taxing purposes only. It certainly would not be of value for any other purpose. You could take a saw and in a few minutes change a given block so that it would go into an entirely different classification. Your classification was therefore entirely artificial and empirical. On the other hand, you *might* have classified your blocks into hard woods and soft woods. You might have gone further and classified your soft woods with reference to certain structures which would have separated the coniferous from the deciduous forms, and continued this segregation to a completion of the group. Such a classification could not be altered by any use of a saw. The block of wood would fall into its correct classification regardless of what was done to it. In other words, it would have been a classification rather than an enumeration. In many of our taxonomic efforts, especially where working with a very small representation of a group or with little knowledge of ancestral forms, our classifications may be very

little better than the long and short sticks of wood, but if we attempt to make a rational classification and follow it as far as our knowledge at the moment permits, correcting it from time to time as our knowledge increases, we are doing the best we can and following the path of the evolution of all knowledge.

There existed for a long period a large school of morphologists who openly ignored and belittled taxonomy. Happily that day is passing. I remember working in a laboratory for a year with an earnest and conscientious young man who was working industriously tracing the development of the lateral line and its sense organs in an embryo of a salamander. I was at the same time working on the evolution (taxonomy if you please) of a certain group of leafhoppers and we used to have frequent arguments as to the value of taxonomy, a value he did not at that time recognize. When, however, he had his work completed and was preparing it for publication he suddenly discovered that there were other genera of salamanders and that the references which he had been consulting were all about a certain common species. Not knowing that there were other genera he had failed to look up these references until his work was completed, and then he found a large volume of morphological work which indicated that there were wide variations in the embryonic development of the three groups, and the poor fellow did not know to which group his original salamander belonged. That was a quarter of a century ago and as far as I am aware he has never been able to name his salamander or publish his results.

Most of you are familiar with the classical case of the entomologist who worked on the spermatogenesis of a certain species of insect or thought he did. He had the species in the wrong genus, worked up the wrong literature, found that it did not agree with the determinations made by European workers, wrote a strong criticism of their work only to have his material re-investigated and the discovery made that he had been wrong in his taxonomy and wrong in his morphology. Although not belonging to the genus, it *did* agree in the morphological changes.

There have been taxonomists who were equally indifferent to the biological and morphological relations of their work. All insects with long spines were placed in the group as against those with short spines. All dark insects were segregated from the light ones, entirely ignoring the fact that the length of spines or the color might easily be adaptations to certain food plants or environment and have occurred independently in groups of widely separated ancestry.

Evolution does not take place in structure alone or in function alone. Variations in animals take place in all lines, in structure, in function, in habit. It is only when we consider all of the factors in their relation to each other that we arrive at a true concept of the path of evolution.

The teaching of economic entomology has departed widely from that of the related sciences. The major portion of our textbooks has dealt with apple insects, corn insects, cotton insects, and the like. The student has a large amount of miscellaneous information of detailed life history and remedial measures centered around a certain crop plant and its environment. Instead he should obtain a thorough understanding of the fundamentals of insect biology so that if he meets a new pest he can apply his fundamental knowledge, and in a majority of cases have a fairly definite idea of the methods to use in control. Instead of getting the details of the 17-year locust in connection with the apple he may well learn that the *Cicadidae* as a group spend a long larval period in the earth, that their resemblance to an army tank is not accidental but an adaptation to that environment. He can then learn that the wireworms as a group also have a long larval period, that in general they have a definite relationship to weed growth or known cultivated crops, and even when he meets an exception to this general rule it will be noted as an exception only to emphasize the fundamental importance of the general adaptation. On the other hand, when he is studying the leaf-feeding forms he will readily realize that short larval periods are absolutely essential to the preservation of the species and will marvel at the many modifications which nature has worked out to adapt insects to the particular favorable period for this larval appearance. Such a course in entomology will train him to think and arouse his interest and enthusiasm, while the other course will be largely a training in memory and the mastery of definite details rather than the working out of principles and the development of theories.

In conclusion I would say that every entomologist should study taxonomy. In fact I would go further—that every entomologist should be a taxonomist in some group, large or small. If every economic worker would carry the responsibility for working out some small unit of our classification he would find it a wonderful stimulus to further development, as well as a broadening influence that would give him a wider series of contacts which would be of value. The aggregate of such small contributions would rapidly advance our knowledge of many little known groups, and if he selected his own economic group

for consideration it might easily change his whole viewpoint of the economic relations.

In the same way I believe every taxonomist should be deeply interested in and a student of the biology of his group, that as far as possible he should work with living material, and that in every case at least one or more species should be studied in large numbers, and thus develop the normal range of variation and adaptation within the species. In this way the systematist would be much clearer in his concept of what constitutes a species and be much more sympathetic with those who are struggling with biologic forms. In a number of fields it is becoming impossible to ignore the fact that there exist definite and fixed biologic forms which we can not, as yet at least, recognize by ordinary taxonomic characters.

Taxonomy as a whole has already reached a position where many divergent lines of proof can be brought to bear, all of which indicates that our major conclusions with reference to the evolution of our groups are accurate. A study of the parasites of the higher animals, for instance, shows a parallel development with that of the hosts. It shows that the parasites have differentiated as the hosts have differentiated. There are internal parasites and external ones; each one of these can be subdivided into different groups, and when the same evolutionary detail can be worked out for all of the groups each one will tend to confirm the accuracy and authenticity of the others. The writer was much interested a few years ago in checking up with Dr. W. D. Pierce on the classification of the Stylops in relation to the classification of the Jassidae and Fulgoridae that they parasitized. The Jassidae as a group are primitive with a certain number of specialized lines. The Fulgoridae as a group are highly specialized with only a few primitive lines. Dr. Pierce's classification of the Stylops indicated that the same relationship held with reference to the parasites. When taxonomy is approached from this standpoint it becomes one of the most valuable forms of biological study and can be recommended as part of the training of every entomologist and a part of the life work of a much larger number than at present.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE GEOLOGICAL SOCIETY

398TH MEETING

The 398th meeting was held at the Cosmos Club January 7, 1925, President STEPHENSON presiding. The Secretary announced the election to active membership of F. E. WHITE.

Program: Dr. LAUGE KOCH, Chief of the Danish Explorations, who spent six years in northern Greenland, addressed the Society on *The geology of Greenland: (1) Physiography and glaciology, (2) Structural geology and stratigraphy.*

399TH MEETING

The 399th meeting was held at the Cosmos Club January 28, 1925, President STEPHENSON presiding.

Program: Prof. FREDERICK J. PACK of the University of Utah addressed the Society on *Scenic aspects of Utah geology.*

HUGH D. MISER: *Erosion in San Juan Canyon, Utah.* The canyon of San Juan River extends west across a high arid region in southeastern Utah and joins the Glen Canyon of Colorado River near the southern boundary of the State. It reveals a magnificent geologic structure section possessing the same dimensions as the canyon, as much as half a mile high and 133 miles long. The rocks aggregate a thickness of 5000 feet and consist of limestone, sandstone, and shale, ranging in age from Pennsylvanian to Jurassic. Most of the rocks are red beds and, since soil is scanty and rock ledges abound, red is the predominating color in any landscape view. The rock strata have been flexed into a broad gentle arch, but neither the arch nor the minor structural features, such as anticlines, synclines, monoclines, faults and joints, have influenced the course of the river.

The present crooked course of the river in the canyon is a striking example of an entrenched meandering stream. Such a course may have been developed on a former cover of Tertiary sediments or on a peneplain, fragments of which stand near and above the walls. The peneplain is possibly of Pleistocene age, and the canyon cutting therefore apparently began in Pleistocene time. The cutting was rapid but did not continue uniformly as there were a few short pauses when the river was graded and deposited gravel which now floors benches of small areas on the walls.

Rock debris, consisting of sand, gravel and boulders, forms the bed of the river and attains a depth of perhaps 100 feet or more. But it is presumably absent in a few of the rapids that are produced by inclined ledges of hard rock which cross the channel. Long stretches of the canyon, where the debris is deepest, present the peculiar example of an alluvial stream flowing between close walls of solid rock, but much of the debris is apparently moved by high floods that take place many years apart.

San Juan River carries an unusually large quantity of debris for streams in the United States and it is one of the chief contributors of mud to Colorado River. The water is always muddy, but during flood stages the river is actually a river of mud; and according to samples taken by Pierce it occasionally carries by volume three times as much silt as water. The heavy load of debris carried during floods causes a peculiar kind of waves known as sand waves.

These waves attain a height of about 7 feet and resemble those thrown up by a stern-wheel river steamboat. They travel upstream, in marked contrast to other kinds of waves that are stationery and also to waves that travel downstream.

If the proposed storage and power projects on San Juan and Colorado rivers are carried to completion the river, on reaching the heads of the reservoirs, will change its work from erosion to deposition. An important question concerning the reservoirs is, How soon will they be filled with rock debris? The answer to this question remains for the future, because the data available at present are not sufficient for making an estimate of the total load of debris that is carried each year by the San Juan and discharged into the Colorado. (*Author's abstract.*)

400TH MEETING

The 400th meeting was held in the Cosmos Club February 11, 1925, President STEPHENSON presiding.

Program: GEORGE P. MERRILL: Early American geologists and their work. (Illustrated with lantern slides.)

DAVID WHITE: *Geologic factors affecting and possibly controlling Pleistocene ice sheet development in North America.* A review of the physiographic and continental changes following middle Tertiary and Pliocene times can not fail to strengthen the idea that the movements of the Pleistocene ice sheets in North America, if not their origin itself, were determined mainly if not wholly by terrestrial factors. It appears more than possible that not only the regulation but the creation also of those ice caps will find adequate explanation in changes of level of the land, great reduction of the epicontinental seas, especially in the temperate and higher latitudes, the expansion of the continental surfaces, the corresponding differences in sub-oceanic topography, and the changes in ocean currents, air currents, rainfall and temperatures consequent to the changes in the land and water.

Among the conditions particularly to be taken into account are the emergence of the continents and the uplift of the higher land masses essentially to the maximum in the course of the post-Tertiary diastrophic revolution which probably is still in progress. Not only are the continental shelves in general unusually exposed, but the epicontinental seas, great stabilizers of continental climates, are in general greatly restricted. The Tertiary seas have largely receded.

The conclusion appears justified that the Laurentian shield embracing the Hudson Bay region was a broad plateau at the close of Tertiary time. Its drainage is an interesting and profitable study. No marine late Cretaceous, no marine Tertiary of any sort, lie on it in some ancient valley or flank it short of the Arctic coast, a great distance to the northwest. It was a land surface on which, in what is now the Arctic British-American Archipelago, fresh-water Tertiary basins existed during late Eocene or Miocene time, with climatic temperatures and rainfall favorable to the growth of temperate arboreal vegetation nearly to the 80th parallel. Within this region the so-called Arctic Miocene flora spread from Alaska through the Arctic islands, central Greenland, Spitzbergen, Nova Zembla, Franz Joseph Land and Siberia, plainly indicating a subsequent climatic revolution that could not take place without critical changes of land and sea. The post-Tertiary revolution lifted the northern lands much higher even than they are now. An elevation of 300 feet, which may well have taken place, would now close Bering Strait, and a

rise of 1200 or 1800 feet in the sea bottom around the north Atlantic would essentially connect up northeastern Europe and northwestern Asia through the islands very nearly to Greenland, leaving narrow and relatively shallow straits. Impressive geographical changes would follow an uplift of 750 feet. The mapping of the sea bottom in this region yields evidence in support of such changes and plant and animal distribution predicate recurrent uplifts or deformations sufficient to permit intercontinental migration of land animals and plants.

The geologic profession is too prone to close its notebook as soon as its feet are wet by tidal salt water. Not only its consecutive constructive thought, but its geological observations too often stop at tide level. The submerged beaches are not less interesting and significant than those so enthusiastically traced around the exposed lands; they may be as numerous and span even greater intervals. The topography and tectonics of the seas, soon to be traced by sonic sounding, are essential portions of the field of geology. The geologic history of the sub-oceanic regions is a subject for study inseparable from that of the land.

The northern Rocky Mountains have been shown to be progressive in growth. They were relatively low at the close of Tertiary time, so as to permit comparatively free transit of moisture-laden winds from the northern Pacific (possibly abnormally warm and moist if Bering Strait was temporarily closed) across to the elevated Laurentian plateau where, due either to post-Tertiary increase in elevation or changes in Arctic climate, the snow and ice of winter might have gained upon the melting capacity of summer's warmth, with consequent development and spread of the glacial ice sheet. Rise of the surface of the ice sheet itself naturally accelerated both the arrest of moisture and, through increased altitude, the lowering of mean temperature.

The strangulation of the north Atlantic and Bering Straits would conduce to great Arctic frigidity, with consequent marked effects on the climates of the northern lands.

Under loading of the ice sheet the shield should in due time have sunk isostatically, presumably with concomitant elevation to a minor extent of the land in portions of the peripheral zone, a procedure fairly well established for the Labrador sheet. Rasmussen reports shore terraces up to an elevation of over 1300 feet on Bylot Island and above 550 feet on Melville Island. Depression of the surface of the region to lower elevations would tend to raise the mean temperature, while retarded temporary elevation of the western border rim which, at maximum extension embraced the foothills, at least, of the Rocky Mountains, could only have cut off a portion of the moisture driven inward from the Pacific. Thus, conditions of reduced precipitation, especially in winter, and lowering of the land, should bring a check in the growth of the ice and reverse the annual increment of winter ice precipitation to annual gain of thaw, which, in due time, automatically would accelerate itself, with the lowering of the ice surface and the uncovering of the land mass. It may do no violence to facts yet observed to assume that the Hudson Bay region has been depressed and uplifted more than once since the development of the first ice sheet. Submerged beaches may alternate in time with some of the raised beaches between which the period of exposure of the land is so commonly distributed.

It is important, however, to note that the ultimate or concomitant mountain-building movement is marked by the final progressive uplift of the Rocky Mountain region, in the course of which morainal deposits on the flank of the mountains were raised to an elevation of around 4500 feet, as has

been noted by Alden. That the termination of Laurentian glaciation may have resulted both from the subsidence of Laurentian land itself on the one hand, and, on the other, the straining of moisture from the warm humid winds drifting from the north Pacific against the risen mountains, with consequent reduction of winter precipitation in the shield province, is indicated by the known elevation of the Rockies during this time, the evident depression of what is now the Archipelago region of British America, and the absence of all marine deposits of Mesozoic or Tertiary age in the entire Hudson Bay basin. This basin is to be viewed as now in the process of isostatic uplift, with slow emptying out of Hudson Bay. An elevation of 300 feet will drain the greater part of the Bay; 1200 feet will dry it. Irregularity of the movement, which was retarded as compared with the more prompt rebound of about 1000 feet in a portion of the Labrador-New England region, is geologically normal. The configuration of the basin, the strand deposits, and the presence of Pleistocene marine fossils at an elevation of 600 feet in the Hudson Bay depression show that the land has rebounded to a certain extent, though the Bay is not yet emptied and its floor is almost certainly many hundreds of feet below its maximum post-Tertiary elevation. Similarly, marine terraces have been noted by P. S. Smith along the north Atlantic coast and by Koch in northern Greenland at elevations of around 700 feet above tide. The argument predicates a continued rise of the Hudson Bay area but does not depend upon it. The great depression of this region is indicated also by the relatively recent (Pleistocene?) diversion of drainage in the western slope from north-south systems eastward into Hudson Bay.

In Eurasia changes of differential elevation and configuration of the land have received much attention, even on the part of biogeographers, but the possible consequent effects on the areas, depths, temperatures, densities and currents of the seas, and the joint effects on radiation, distribution of cyclonic centers and other climatic factors affecting the land do not seem to have engaged the close consideration that they deserve.

Obviously, outward movements of the continental shore lines, with closing (partial at least) of Arctic connections, which may tentatively be assumed to have occurred, and the assured existence of extensive ice sheets in the northern hemisphere could not fail, through their effects on water and air currents, to affect prevailing winds and weather in the subtropical and even the tropical areas, and, by disturbance of the equilibrium, in the Equatorial belt, with diversion of atmospheric currents, may well have affected the normal drift of warm air into the Antarctic zone. This is probable, regardless of the certain effects of post-Tertiary Andean uplift. If true it would favor the development of climatic cold and ice in the Antarctic regions contemporaneously, or nearly contemporaneously, with the growth of glacial sheets and extreme cold in the north. It will be recalled that Arctic mammals were driven into the lower Mississippi valley, while many indigenous plants and animals, including the horse, were exterminated.

The premises outlined above suggest factors possibly explanatory both of shifting in the areas of ice expansion and of some features of Cordilleran glaciation. The elevation of the interior region of North America in late Tertiary time, with the consequent expulsion of the sea from the Central region and even from the Mississippi embayment, taken in conjunction with the low stand of the Rocky Mountains at the earliest stage of the Pleistocene, would be favorable for the great extension of the earliest glaciation, Nebraskan and Kansan, to more southern limits in the Great Plains region. On the other hand, the growth of the Rocky Mountains from the south, with increas-

ing interference with transit of wind-borne humidity to that region, must have restrained the expansion of the later ice caps in that direction without corresponding effect on the spread of the northeastern sheets.

Similarly, the widespread glaciation of the Sierras while the Coast Ranges were relatively low contrasts strongly with the relatively restricted extent of the later glaciation at a time when the Coast Ranges were much more fully developed. Mountain growth to the west and consequent interference with precipitation on the Sierras may have terminated glaciation in this region, just as in the north, though, on the other hand, it is left to the glacialist and the climatologist to determine whether ice growth in the Sierra regions was not dominated by the causes and the growth itself of the great Laurentian sheets.

The author does not deny the possible effects of astronomical phenomena on earth climate. Variation in solar radiation, even for short periods like the three years of deficiency just past, may cause notable changes in ocean currents and air currents, with consequent marked effects on climate that may be felt in most unexpected quarters, once the approximate climatic equilibrium is disturbed, and by shifting and producing "highs" and "lows" of atmospheric pressure may touch off earthquakes, influence volcanic action, and if continued sufficiently long may cause isostatic adjustment. Pleistocene glaciation may, in his belief, largely if not wholly be explained by terrestrial rather than astronomical changes. At least the geologist should not look unto the heavens for help in the solution of his problem before he has duly and most earnestly considered all the facts already within his reach. The object of this presentation is to stimulate study of the questions here speculatively set forth. The more important evidence has to do with continental exposure, elevation, and configuration, Quaternary mountain building, elimination or reduction of epicontinental seas, migration of shore lines, strangulation of Arctic circulation, great changes in currents and temperatures of water and air, and changes in season and amount of precipitation.

The problem is one demanding the attention not only of the geologist, but of the oceanographer and the meteorologist, as well as the geographer. Its best solution can not be reached without their closest cooperation. When the causes of glaciation in Pleistocene time are determined it will be in order to consider the glaciations of earlier epochs. (*Author's abstract.*)

401ST MEETING

The 401st meeting was held in the Cosmos Club February 25, 1925, President STEPHENSON presiding. The Secretary announced the resignation from active membership of J. B. EBY.

Program: C. D. WALCOTT: *Robson Peak section.* (Illustrated with lantern slides.)

R. S. BASSLER: *The stratigraphic use of conodonts.* (Illustrated with lantern slides.) Certain Paleozoic formations particularly black shales, are often crowded with tooth-like fossils averaging a millimeter in diameter, resembling in part microscopic sharks' teeth. In 1856 a monograph upon Russian examples of these fossils was published by Pander who termed them "conodonts." Since then the systematic position of the conodonts has been much in question and little work of systematic value has been published upon them partly because it was believed that these structures were too variable to be of stratigraphic value. A detailed study of the ample collections of conodonts in the U. S. National Museum by E. O. Ulrich and the writer has

resulted in a classification of the group, which, if not entirely natural, has proved very useful in correlation. The work has also convinced us that the conodonts are the teeth of primitive fishes of perhaps several distinct groups and that the supposed great variability of structure in the same species does not exist. The conodonts show a marked evolution from simple undenticulated teeth in the Ordovician to complex forms with a main cusp and complicated denticulation in the Mississippian. Their value as horizon markers was proved particularly in working out the correlation of the Devonian and Mississippian black shales in the Eastern part of the United States, identical faunas having been found scattered over a wide range of country. (*Author's abstract.*)

WM. C. ALDEN: *Glaciation and physiography of Wind River Mountains, Wyoming.* Remnants of several finely developed sets of gravel-capped, cut terraces ranging from 15 or 30 feet to 1500 feet above the streams indicate successive notable stages of still-stand and stream planation alternating with stages of regional uplift. These have been described by Blackwelder, Westgate, and Branson and others. The Lenore terrace 15 to 30 feet above the streams is generally confined between the lines of bluffs. The moraines of the last, the Pinedale (or Wisconsin) stage of glaciation, extend down onto the Lenore terrace.

One to two hundred feet above the Lenore terrace is the Circle terrace. The moraines of the next older, or Bull Lake stage of glaciation, extend down onto but not below the Circle terrace. Some notable shifts in the locations of streams and valleys took place after the Bull Lake stage (which may correspond to the Iowan stage of the Keewatin ice sheet) and prior to the Pinedale stage. The Circle terrace seems to correspond to the main, or lower level of the second set of terraces throughout the Yellowstone drainage basin. There are scattered remnants of much more eroded higher and older sets of terraces some of which may correspond to the higher level of the second set of terraces on the Yellowstone of early Pleistocene age.

The highest tablelands 1000 to 1500 feet above the streams, represented by the top of Table Mountain near Lander, are remnants of a vast gravelly alluvial piedmont terrace (the Table Mountain plain). This is believed to have been completed in Pliocene time and to be the correlative of Meeteetse terrace in Big Horn Basin and of the Flaxville and associated terraces of Montana. The much-weathered deposits of big boulders capping Table Mountain and other remnants are believed (in part at least) to have been deposited by mountain glaciers on the Table Mountain piedmont terrace before it was much dissected. This is probably as old as, or older than, Blackwelder's "Buffalo drift" of the Wind River and Teton Mountain region. It is probably the correlative of similar deposits of early Pleistocene age on high mesas at the east front of Big Horn Mountains, and of the oldest mountain glacier drift (Nebraskan) on the highest benchlands in the region of Glacier National Park.

Several thousand feet above the Table Mountain remnants is the summit peneplain or plateau on Wind River Mountains, the product of Blackwelder's Fremont cycle of erosion. In the opinion of the writer this is older than Pliocene, possibly Miocene or Oligocene. Notable regional uplifts followed both the development of this peneplain and that of the Table Mountain plain. The latter uplift probably closed the Tertiary, brought on the first mountain glaciation, and started the streams to dissecting the Table Mountain plain or piedmont terrace. These correlations are, as yet, tentative. (*Author's abstract.*)

402D MEETING

The 402d meeting was held in the Cosmos Club March 11, 1925, President STEPHENSON presiding. The Secretary announced the election to active membership of R. L. FAHIS.

Program: E. T. ALLEN: *Further evidence of the nature of hot springs.* (Illustrated by lantern slides.) Drilling for natural steam as a source of power has been in progress for some time at a place called "The Geysers," Sonoma County, California. "The Geysers" are situated in the St. Helena Mt. Range. The hot areas in this locality extend along the side of a narrow canyon, occurring at intervals for a distance of about six miles. No igneous rocks, lava or volcanic ejecta have been discovered in the immediate neighborhood; the rocks are sandstones, shales, serpentines, schists, and other metamorphics. At The Geysers sandstone is encountered by drilling at a depth often less than 100 feet from the surface. The temperature close to the surface is very generally near 100°C. As cracks are cut by the drill the steam flow increases and the temperature rises rapidly—25°C. or more per 100 ft. in the upper strata, and measurements show that water could not penetrate to any considerable depth without being vaporized. Small hot springs often of high mineral concentration are frequent. Their maximum temperature reaches about 98°C.—the boiling point of water for the elevation. The mineral matter in the springs is chiefly sulphate and acid sulphate of ammonium and magnesium, or in the alkaline springs carbonate, bicarbonate and sulphate. The evidence shows that the volatile matter is derived from the volcanic gases which are escaping from springs and fumaroles. The non-volatile matter is derived from the serpentine and other metamorphic rocks and of the area. That it comes from rocks near the surface is supported by the fact that surface water can not penetrate deeply and fresh pyrite in the sandstone drillings shows that oxidation also extends only to shallow depths.

The phenomena of The Geysers are best accounted for on the assumption that superheated steam and other volcanic gases are ascending from a hot batholith through a deep crack in the overlying strata; that the steam is heating surface water by condensation, and the gases, hydrogen sulphide and carbon dioxide through logical chemical changes are decomposing the superficial rocks (*Author's abstract.*)

W. H. BRADLEY: *An interpretation of the Green River formation.* (Illustrated by lantern slides.) The field observations on the Green River formation and study of the microfossils of the oil shale together with the application of the principles of limnology to the interpretation of these lake beds indicate the following trend in the formation's geologic history.

The Green River lakes were initiated, by gentle downwarping of the basin floors, as large and relatively stable though quite shallow fresh water lakes in which flourished an abundant flora and an active fauna. Limy shale, oolitic limestone, sandstone, and a small amount of low grade oil shale were deposited in the lakes of this stage.

The lakes of the second stage were still shallower and under climatic influence repeatedly filled and evaporated either partially or completely. At the beginning of the cycle they may be pictured as broad sheets of clear and fresh or moderately alkaline water, but at the close of the cycle, after a long, hot, dry season, as a large number of disconnected ponds of various sizes and various degrees of alkalinity. Plankton organisms, mostly algae and Protozoa, thrived in these ephemeral ponds and reduction in volume not only greatly

concentrated those already present, but also stimulated a vastly greater production of them by reason of the stagnation and corresponding rise in temperatures of the water. Active putrefaction, probably also assisted by the activity of saprophytic fungi, protozoans, various round worms, and minute crustaceans reduced the dead organisms to a nearly structureless jelly. Organic acids resulting from the putrefaction together with the increasing content of dissolved mineral salts finally became effective toxins and the ooze became an almost perfectly antiseptic medium. This structureless, semifluid organic ooze with its occluded algae, fungi, protozoa, pollen, and spores together with various proportions of finely divided mineral matter was then covered by the deposits of the next cycle and subsequently lithified into oil shale.

The closing phase of Green River deposition was characterized by strongly alkaline lakes, probably playa-like, in the wet muds of which considerable glauberite crystallized out. The conditions of deposition of this third phase were evidently too unfavorable for the growth and accumulation of large quantities of microorganisms and only an insignificant amount of oil shale resulted. A period of vigorous stream abrasion terminated the alkaline playa phase and was followed by the deposition of stream channel sands and fluvial clay which now make up the top of the Green River formation. (*Author's abstract.*)

KIRK BRYAN: *Recent deposits of Chaco Canyon, New Mexico, in relation to the life of the pre-historic peoples of Pueblo Bonito.* (Illustrated by lantern slides.) The part of the valley of Chaco River known as Chaco canyon lies on the southern border of San Juan Basin, New Mexico, and is about 12 miles long, from 1 to 3 miles wide, and 200 to 400 feet deep. The ruins of 13 large communal houses stand on the canyon floor and the adjacent cliffs and with numerous smaller ruins testify to the flourishing civilization that once existed in this now desolate region. Pueblo Bonito, the largest of these ruins, is now being excavated by an expedition under Neil M. Judd, organized and supported by the National Geographic Society. The geologic work here recorded in a preliminary statement was done at the instance of Mr. Judd and at the expense of the Society.

The flat floor of Chaco Canyon is marked by a relatively recent gully in which the floods of Chaco River are now wholly confined. This gully, or arroyo, is now from 150 to 450 feet wide and 30 feet deep at Pueblo Bonito. In 1877 it was 40 to 60 feet wide and 16 feet deep. An exploring expedition in 1849 makes no mention of an arroyo and it therefore seems likely that the arroyo was initiated at about the same time as the similar gullies in other southwestern canyons, i.e., since the year 1870.

The alluvial deposits that form the floor of the canyon are of unknown thickness, but the upper 30 feet is well exposed in the walls of the arroyo. The sand, silt, "adobe," and gravel of this valley fill are all characteristic of deposition in muddy floods similar to those of the present ephemeral stream and give no evidence that the Canyon ever had a perennial water course. The agriculture of the prehistoric peoples was, therefore, not carried on by irrigation with living water but probably by the methods of floodwater farming—a system still in use in the region.

Relics of man, in the form of hearths, bone fragments, potsherds, etc., are found to a depth of 21 feet. The zone from 4 to 6 feet below the surface contains the remains of the people who built the large ruins and was therefore deposited in the Pueblo period. The zone from 6 to 21 feet contains the relics

of pre-Pueblo peoples. In addition to this normal relation showing a transition in the type of human culture with the progress of alluviation of the valley, there is a buried channel containing potsherds of the latest type known in Pueblo Bonito. The buried channel is from 15 to 18 feet deep and has been traced a total distance of 1500 feet. It was evidently formed and refilled either very late in the occupancy of Pueblo Bonito or shortly after its abandonment, and represents a post-Bonito or post-Pueblo period.

If this buried channel represents a period of erosion followed by a period of sedimentation intervening between the period of alluviation that formed the main valley fill and the present period of erosion which began in 1870, very important consequences result. The formation of the channel would have so reduced the agricultural area subject to floodwater farming as to furnish an approximate cause for the abandonment of Pueblo Bonito. The refill of the channel would have restored the flood plain to a condition nearly like its original condition and thus would have provided conditions suitable for the expansion of the Navajo tribe in the years before and since the Spanish conquest.

Further investigation is planned for the purpose of tracing this buried channel and further unravelling the history of the valley fill. Since, however, the various members of the complex mass of otherwise similar sediments contain potsherds of characteristic type, the problem can be attacked by ordinary stratigraphic methods in which potsherds take the place of fossils. (*Author's abstract.*)

403D MEETING

The 403d meeting was held in the Cosmos Club March 25, 1925, Vice-President HEWETT presiding.

Program: W. T. SCHALLER: *Genesis of lithium pegmatites.* (Illustrated with lantern slides.) Studies in the field and laboratory of the lithium pegmatites of southern California and laboratory studies of similar specimens from other localities have shown that these pegmatites as now composed are not original crystallizations from a magma but are a hydrothermal replacements of a much simpler, earlier formed, magmatic rock free from any lithium minerals. In the California field graphic granite was the earlier rock replaced, the well-defined texture of graphic granite serving as a "key" for the determination of the replacement processes. In volume percentage, albite is the chief mineral replacing both the microcline and quartz of the graphic granite. Other stages of the replacement show that the albite was later replaced by lithium minerals. The well known rubellite and lepidolite specimens were shown to have been originally graphic granite. Other pegmatitic minerals accompanying the albitic and lithium mineralic replacements include muscovite, biotite, garnet, black tourmaline, beryl, columbite, etc. The original pegmatitic magma was therefore not rich in the so-called mineralisers, all of which were introduced later in the hydrothermal replacement processes. The formation of some of these minerals in bands and the formation of crystal lined cavities are likewise due to the replacement processes. (*Author's abstract.*)

FRANK L. HESS: *Oolites.* (Illustrated with lantern slides.) Some oolites from Carlsbad Caverns, New Mexico, were turned over to the speaker for study. They were formed through the precipitation of calcium carbonate in small pools under stalactites, the drip from which stirred the water of the pools,

so that precipitating lime carbonate was kept in motion. It was shown by other examples, including calcium carbonate oolites, formed in boiling sugar refuse; nickel oolites formed from gas in the regular production of nickel by the Mond carbonyl process; sulphur oolites formed in crater lakes from sulphurous gases bubbling through the water; halstones apparently formed through the precipitation of ice from gaseous H_2O ; and oolites formed in Great Salt Lake from calcium carbonate brought down by streams, that the same principle governed the formation of all these different types of oolites, that is, that many solids precipitated in a moving fluid take on an oolitic form, and it is therefore unnecessary to call on the aid of bacteria or other more or less mysterious agencies to explain the formation of oolites. Calcite, hematite, phosphorite and oolites have apparently all been formed in the same way. (*Author's abstract.*)

W. P. WOODRING: *Miocene climate of tropical America*. (Illustrated with lantern slides.) At the close of Miocene time many genera of marine animals suddenly disappeared in the Caribbean Sea and adjoining waters of the Gulf of Mexico and Atlantic Ocean. Most of these genera that are now living are found in the warm waters of the eastern Pacific and some are confined to the tropical western Pacific. Therefore it seems probable that in its physical features the Miocene Caribbean Sea resembled the present tropical Pacific. Among the mollusks characteristically tropical families such as the Terebridae, Conidae, Cancellariidae, Mitridae, Columbellidae, Cypraeidae and Arcoideae had a much richer representation in the Miocene Caribbean Sea than in the present Caribbean Sea. The whole Miocene Caribbean fauna had a more tropical aspect than the living fauna.

Perhaps the most significant feature accounting for the change in the Caribbean Sea and the extinction there of Pacific genera lies in the closing of the channels that extended across Panama and Costa Rica during Miocene and earlier Tertiary time. The problem of the effect of these channels on oceanic circulation can hardly be avoided even though available data may be too meager to attempt to evaluate its significance. All geologists who are familiar with Central America agree that the channels were open during at least parts of Eocene, Oligocene, and Miocene time and were closed after middle Miocene time. Some geologists believe that water from the Caribbean Sea was transferred into the Pacific across the Central American channels. It seems more probable that the slightly higher mean sea level in the Pacific and the much greater tidal range on the Pacific side of Central America would cause a movement in the opposite direction, carrying into the Caribbean Sea water having the same temperature, salinity, and food supply as Pacific water, and offering a means of transporting pelagic larvae. As the Tertiary faunas of the Pacific coast of Central America and northern South America are being studied, it is becoming apparent that, at least so far as the mollusks are concerned, many of the Pacific genera that have disappeared in the Caribbean Sea were autochthonous in the eastern Pacific. They moved into the Caribbean Sea as temporary migrants and remained there only as long as the channels were open. This explanation is far from satisfactory when an attempt is made to apply it to genera that were established in the Caribbean Sea during the long period from Eocene to Miocene and even spread as far north as the southeast coast of the United States. It is purely speculative, but it seems to offer a reasonable basis to account for the striking change in the Caribbean fauna—a change caused by the elimination or impoverishment of genera and families that are characteristically tropical. (*Author's abstract.*)

404TH MEETING

The 404th meeting was held in the Cosmos Club April 8, 1925, Vice-president BUTTS presiding.

Program: J. B. MERTIE, JR.: The Paleozoic geology of interior Alaska. The oldest rocks in Alaska comprise a group of rocks, known collectively as the Birch Creek Schist, which crop out typically in the valley of Tanana River, in interior Alaska. These consist essentially of quartz-mica schist of sedimentary origin, together with orthogneiss and metamorphosed basic igneous rocks. The schist is of pre-Ordovician and probably of pre-Cambrian age. The included metamorphic igneous rocks may be in part of early Paleozoic age.

Overlying unconformably the Birch Creek Schist in its type locality is a great thickness of slate and metamorphosed arkose, known as the Tatalina group, in the upper part of which occur lower Ordovician fossils; and at the very top of the Tatalina group is found a formation of metamorphosed basaltic lavas, in the tuffs of which late middle Ordovician fossils occur. To the eastward, along the international boundary, rocks which are believed to be stratigraphically equivalent to the Tatalina group contain fossils ranging in age from middle Cambrian to upper Ordovician; while to the southward and southwestward, both Utica and Richmond horizons in the upper Ordovician have been recognized, the former being essentially an argillaceous and the latter a limestone formation.

Lower Silurian rocks have not been found in the interior of Alaska, but middle Silurian rocks are widespread and form one of the best known horizon markers in the Paleozoic section. The type locality is in Brooks Range, of northern Alaska, where a middle Silurian limestone about 6000 feet thick, extends for more than 500 miles from east to west across the Territory. A similar limestone of like age is found in the Yukon-Tanana region, and along the international boundary. Upper Silurian time is represented in northern Alaska by a formation of slate, quartzite and relatively thin bands of limestone; and rocks of similar character and age, in the Yukon-Tanana region are grouped together under the designation Tonzona group.

A great structural unconformity is believed to separate the Silurian rocks from the overlying Devonian rocks; and during this stratigraphic hiatus in lower Devonian time, granitic rocks, now gneissoid, are believed to have originated in Northern Alaska, and perhaps in the Yukon-Tanana region. The succeeding middle and upper Devonian rocks, and the base of the Mississippian sequence of northern Alaska, are essentially quartzitic sandstone and slate, with some limestone beds. These rocks are strikingly free from igneous intrusives and extrusives but south of Brooks Range, and particularly in the Yukon-Tanana region, ancient basic lavas are interbedded with middle Devonian limestones, and ultra-basic intrusives, believed to be of upper Devonian age, are found. Similarly, in the Yukon basin, another great series of basic lavas and intrusives, known as the Rampart group, are found, which contain Mississippian fossils in their tuffaceous members.

The Carboniferous rocks of northern Alaska include the basal sandstones and shales, known as the Noatak formation; an overlying formation of limestone and chert, known as the Lisburne formation; and possibly a still higher chert formation, all three being of Mississippian age. The Lisburne formation, like the Silurian limestone, is a well defined horizon marker, extending 600 miles east-west across the Territory. The Pennsylvanian is represented by the Sadlerochit sandstone, but in northern Alaska, Permian rocks have

not been found. Southward, in the Yukon basin, several formations of Carboniferous rocks are known. The Mississippian rocks include the Rampart volcanics, the Calico Bluff formation composed of thin-bedded shale and limestone, the Livengood Chert formation, and a chert-argillite (?) group of rocks. These formations occur at different localities, and the stratigraphic relations between them are therefore obscure. The Pennsylvanian is believed to be represented by the Nation River formation, which may be in part of non-marine origin; and the Permian is represented by a marine highly fossiliferous limestone.

A regional uplift of all of Alaska began in late Carboniferous time, culminating perhaps in the lower Triassic, with the resumption of marine sedimentation in the upper Triassic. This elevation was of the continental type and was accompanied by a minimum of rock deformation and mountain building, though it doubtless resulted in tilting and some folding of the rocks. In Jurassic time, however, another great elevation of interior Alaska occurred, accompanied by orogenic movements of the first magnitude, and the intrusion of great granitic batholiths. It was during this, and subsequent periods of similar tangential thrusting from the south, in Cretaceous and Tertiary time, that the late Paleozoic rocks of interior Alaska acquired their present complex structure. (*Author's abstract.*)

GEORGE C. MARTIN: *The Mesozoic rocks of Alaska.*

PHILIP S. SMITH: *Fields for future Alaskan studies.* (Illustrated with lantern slides.) The speaker exhibited a map of Alaska on which were distinguished the areas that have or have not been surveyed by the U. S. Geological Survey in the territory. He discussed the physical condition of the various unsurveyed tracts and the major geologic problems of each and pointed out those areas which because of their promise of containing mineral deposits of value were most worthy of early investigation. Large tracts of the lowlands adjacent to the coast which because of their physical condition afford little information to the geologist regarding the unusual resources and which because of their swamps will be extremely expensive to map, will probably not be surveyed until airplanes or some other effective means of transportation are available. (*Author's abstract.*)

EDWARD SAMPSON, J. D. SEARS, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

Dr. E. W. WASHBURN has been appointed Chief of the Chemistry Division, Bureau of Standards to succeed Dr. W. F. HILLEBRAND, whose death occurred about a year ago. Dr. WASHBURN is a graduate of the Massachusetts Institute of Technology with the degrees of B.S. and Ph.D. He was on the staff of the University of Illinois from 1908 to 1922 as Professor of Physical Chemistry and as Head of the Department of Ceramic Engineering. For the past three years he has served as Editor-in-Chief of the International Critical Tables. His principal research work has been on the hydration of ions, theory of solutions, and the high temperature chemistry and physics of ceramic materials.

Dr. SEWALL WRIGHT, formerly of the U. S. Department of Agriculture, has been appointed associate professor of zoology at the University of Chicago.

The Ore Deposits Club met on Friday evening, January 22, at the Geological Survey. Messrs. LOCKE and KINGSBURY discussed *Mineralisation stopping*.

A circular has been issued by Chairman DAVID WHITE on behalf of the Division of Geology and Geography of the National Research Council, in cooperation with the Geological Society of America, outlining plans for the Fourteenth Geologic Congress which will be held at Madrid, Spain, May 24 to 31, with excursions preceding and following these dates. A number of Washington geologists are planning to attend the Congress.

Obituary

Dr. WILLIAM EDWIN SAFFORD, a member of the ACADEMY and a frequent contributor to its Journal, died of pneumonia on January 10, in his 67th year. After more than twenty years' service in the United States Navy, during which he acted for one year (1899-1900) as vice-governor of Guam. Dr. SAFFORD entered the Department of Agriculture in 1902 and was at the time of his death economic botanist of the Bureau of Plant Industry. Dr. SAFFORD was a man of unusually broad interests and pronounced linguistic and literary ability, whose numerous publications on economic plants were enriched by his knowledge of ethnology, art, and languages. During his service in the Department of Agriculture he devoted himself particularly to the study of the plants and plant products used by the American aborigines, especially of the tropics, and of the early history of the cultivated plants both of the Old and the New Worlds. At the time of his death he was bringing to completion a work on the useful plants of Mexico. His principal botanical publications include a flora of the island of Guam and revisionary works dealing with the Annonaceae and the bullhorn acacias.

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

VOL. 16

FEBRUARY 19, 1926

No. 4

MATHEMATICS.—*Transformations associated with the Lorentz group.*¹

CHARLES BARAFF, U. S. Patent Office. (Communicated by
L. H. ADAMS.)

Einstein's special relativity theory transformation² is:

$$\left. \begin{aligned} x_1 &= \beta (x - vt) \\ y_1 &= y \\ z_1 &= z \\ t_1 &= \beta \left(t - \frac{vx}{c^2} \right) \end{aligned} \right\} (1)$$

where $\beta = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$

Another form of this transformation is:

$$\left. \begin{aligned} x_1 &= x \cos \theta + ict \sin \theta \\ y_1 &= y \\ z_1 &= z \\ t_1 &= t \cos \theta + \frac{x i}{c} \sin \theta \end{aligned} \right\} (2)$$

where $\theta = \tan^{-1} \frac{vi}{c}$ and c = constant velocity of light. Minkowski³ calls this form the special Lorentz transformation group.

¹ Received January 16, 1926.

² EINSTEIN, A. *Annalen d. Physik* 17: 891. 1905.

³ MINKOWSKI, H. *Grundgleichungen für die elektro-magnetische Vorgänge*, p. 10.

Still another equivalent form is:

$$\left. \begin{aligned} x_1^2 - c^2 t_1^2 &= x^2 - c^2 t^2 \\ y_1 &= y \\ z_1 &= z \\ x_1 - ct_1 &= e^{-i\theta} (x - ct) \end{aligned} \right\} (3)$$

where $\theta = \tan^{-1} \frac{v}{c} = \cos^{-1} \beta$

The above equations represent the finite transformations of the special relativity theory. They may be derived by integrating the differential equations

$$\frac{dx_1}{ct_1} = \frac{c dt_1}{x_1} = \frac{dy_1}{0} = \frac{dz_1}{0} = i d\theta \quad (4)$$

the initial conditions being that when θ or $v = 0$ then

$$\begin{aligned} x_1 &= x \\ y_1 &= y \\ z_1 &= z \\ t_1 &= t \end{aligned}$$

The most general function of the space time coördinates that remains invariant to the special relativity transformation is derived from the integration of the partial differential equation:

$$ct \frac{\partial f}{\partial x} + \frac{x}{c} \frac{\partial f}{\partial t} = 0$$

the solution of which is

$$f(x^2 - c^2 t^2, y, z)$$

If set equal to zero, to wit, $f = 0$ represents the most general space time configuration that is unaffected or invariant to a special relativity transformation. This is a three dimensional surface in a four dimensional space time universe.

The physical interpretation of invariants in this paper is that they are quantities or the relations of quantities which appear alike to a stationary observer and to an observer moving uniformly relative to the stationary observer. They are relations which have the same form both in a stationary system and in a moving system.

II

The special relativity transformations of velocities are:

$$\left. \begin{aligned} u'_x &= \frac{u_x - v}{1 - \frac{vu_x}{c^2}} & u'_y &= \frac{u_y}{\beta \left(1 - \frac{vu_x}{c^2}\right)} \\ u'_z &= \frac{u_z}{\beta \left(1 - \frac{vu_x}{c^2}\right)} \end{aligned} \right\} (5)$$

Their derivation follows easily from the Lorentz form, for differentiating,

$$dx_1 = dx \cos \theta + ic \, dt \sin \theta$$

$$dy_1 = dy$$

$$dz_1 = dz$$

$$dt_1 = dt \cos \theta + \frac{dx}{c} \sin \theta$$

Dividing dx_1 by dt_1

$$\frac{dx_1}{dt_1} = \frac{\frac{dx}{dt} + ic \tan \theta}{1 + \frac{i}{c} \tan \theta \frac{dx}{dt}} = \frac{u_x - v}{1 - \frac{vu_x}{c^2}}$$

Similarly:

$$\frac{dy_1}{dt_1} = \frac{\frac{dy}{dt}}{\cos \theta \left(1 + \frac{i}{c} \tan \theta \frac{dx}{dt}\right)} = \frac{u_y}{\beta \left(1 - \frac{vu_x}{c^2}\right)}$$

$$\frac{dz_1}{dt_1} = \frac{u_z}{\beta \left(1 - \frac{vu_x}{c^2}\right)}$$

This is the same result as that obtained by Einstein⁴ from the consideration of the invariance of the Maxwell equations toward the

⁴ EINSTEIN, A. *Jahrbuch d. Radioaktivität und Elektronik*, 1907 p. 411

special relativity transformation. Here the components of velocity were the u_x, u_y, u_z in the equations:

$$\left. \begin{aligned} \frac{\partial N}{\partial y} - \frac{\partial M}{\partial z} &= \frac{1}{c} \left(\rho u_x + \frac{\partial X}{\partial t} \right) \\ \frac{\partial L}{\partial z} - \frac{\partial N}{\partial x} &= \frac{1}{c} \left(\rho u_y + \frac{\partial Y}{\partial t} \right) \\ \frac{\partial M}{\partial x} - \frac{\partial L}{\partial y} &= \frac{1}{c} \left(\rho u_z + \frac{\partial Z}{\partial t} \right) \end{aligned} \right\} (6)$$

By means of the special relativity transformation, this equation, which is one of Maxwell's four fundamental equations, passes over into the equation

$$\left. \begin{aligned} \frac{1}{c} \left(\rho' u_x' + \frac{\partial X'}{\partial t'} \right) &= \frac{\partial N'}{\partial y} - \frac{\partial M'}{\partial z} \\ \frac{1}{c} \left(\rho' u_y' + \frac{\partial Y'}{\partial t'} \right) &= \frac{\partial L'}{\partial z} - \frac{\partial N'}{\partial x} \\ \frac{1}{c} \left(\rho' u_z' + \frac{\partial Z'}{\partial t'} \right) &= \frac{\partial M'}{\partial x} - \frac{\partial L'}{\partial y} \end{aligned} \right\} (7)$$

where u_x', u_y', u_z' have the values in terms of u_x, u_y, u_z given in Equation (5).

It should be noted that the transformation equations for velocities also form a group of one-parameter transformations. They may be derived from the differential equations

$$\frac{u_x' du_x'}{c \left(1 - \frac{u_x'^2}{c^2} \right)} = \frac{c du_x'}{-u_y} = \frac{c du_x'}{-u_z} = i d\theta u_x'$$

by integration, with the initial conditions that when

$$\theta \text{ or } v = 0$$

then

$$u_x' = u_x$$

$$u_y' = u_y$$

$$u_z' = u_z$$

The most general distribution of velocities that remain invariant to the special relativity transformation are determined by the partial differential equations:

$$ct \frac{\partial f}{\partial x} + \frac{x}{c} \frac{\partial f}{\partial t} + c \left(1 - \frac{u_x^2}{c^2} \right) \frac{\partial f}{\partial u_x} = 0$$

$$ct \frac{\partial f}{\partial x} + \frac{x}{c} \frac{\partial f}{\partial t} - \frac{1}{c} u_x u_y \frac{\partial f}{\partial u_y} = 0$$

$$ct \frac{\partial f}{\partial x} + \frac{x}{c} \frac{\partial f}{\partial t} - \frac{1}{c} u_x u_z \frac{\partial f}{\partial u_z} = 0$$

The solution of the first is:

$$\frac{ct - \frac{xu_x}{c}}{x - tu_x} = f_1(x^2 - c^2t^2, y, z)$$

This gives a velocity X -component for any assigned point of space, and any instant. The substitution of u_x in the second and third equations and the integration thereof results in values for u_y and u_z in terms of x, y, z, t .

III

Accelerations are transformed by the special theory of relativity as follows:

$$\frac{d^2x_1}{dt_1^2} = \frac{\frac{d^2x}{dt^2}}{\beta^2 \left(1 - \frac{vu_x}{c^2} \right)^3}$$

$$\frac{d^2y_1}{dt_1^2} = \frac{\frac{d^2y}{dt^2}}{\beta^2 \left(1 - \frac{vu_x}{c^2} \right)^3} + \frac{\frac{vu_y}{c^2}}{\beta^2 \left(1 - \frac{vu_x}{c^2} \right)^3} \frac{d^2x}{dt^2}$$

$$\frac{d^2z_1}{dt_1^2} = \frac{\frac{d^2z}{dt^2}}{\beta^2 \left(1 - \frac{vu_x}{c^2} \right)^3} + \frac{\frac{vu_z}{c^2}}{\beta^2 \left(1 - \frac{vu_x}{c^2} \right)^3} \frac{d^2x}{dt^2}$$

These relations may be easily derived thus:

$$\frac{dx_1}{dt_1} = \frac{d}{dt_1} \frac{dx}{dt} = \frac{d \left(\frac{u_x - v}{1 - \frac{vu_x}{c^2}} \right)}{\beta \left(dt - \frac{v}{c^2} dx \right)}$$

$$\frac{d^2 x_1}{dt_1^2} = \frac{\frac{du_x}{dt}}{\beta^2 \left(1 - \frac{vu_x}{c^2} \right)^2} = \frac{\frac{d^2 x}{dt^2}}{\beta^2 \left(1 - \frac{vu_x}{c^2} \right)^2}$$

Similarly:

$$\frac{d^2 y_1}{dt_1^2} = \frac{d}{dt_1} \frac{dy_1}{dt_1} = \frac{d \left(\frac{u_y}{\beta \left(1 - \frac{u_x v}{c^2} \right)} \right)}{dt_1}$$

$$\frac{d^2 y_1}{dt_1^2} = \frac{\frac{d^2 y}{dt^2}}{\beta^2 \left(1 - \frac{vu_x}{c^2} \right)^2} + \frac{\frac{v}{c^2} u_y \frac{d^2 x}{dt^2}}{\beta^2 \left(1 - \frac{vu_x}{c^2} \right)^2}$$

Likewise for $\frac{d^2 z_1}{dt_1^2}$.

These equations for the transformation of accelerations are contained in the differential equations:

$$\frac{dw_x'}{3 u_x w_x'} = \frac{dw_y'}{2 u_x w_y' + w_x' u_y} = \frac{dw_z}{2 u_x w_z' + w_x' u_z} = ic d\theta$$

from which they result by integration with the initial conditions that when

$$\theta \text{ or } v = 0,$$

then

$$w_x' = w_x$$

$$w_y' = w_y$$

$$w_z' = w_z$$

Here $w_x' = \frac{d^2 x_1}{dt_1^2}$ etc.

In a future paper, the writer hopes to develop the consequences of these abstract formulae to the concrete relations and phenomena occurring in mechanics, astronomy, and electricity.

I beg to acknowledge the inspiration of my sister Ella in this work.

METEOROLOGY.—*A lightning stroke.* N. ERNEST DORSEY.

The detailed examination of a tree (height 47 feet, girth near ground 49 inches) which had recently been struck by lightning brought to light a number of facts¹ which do not readily conform to the usual ideas regarding the nature of a lightning stroke. Some of the more striking are these: (1) The tree was surrounded by the following objects, each about half the height of the tree distant from it: To the northwest was a tower which was $\frac{1}{2}$ higher than the tree; a tree of essentially its own height was to the southwest, another to the south and a third to the southeast, a tree about half as high was to the west and another to the north of east. Though surrounded in this manner, it was struck at an altitude of less than $\frac{1}{2}$ its height. At about twice its height distant, and on the other side of the building with the tower, was a tree of the same kind, about $\frac{1}{2}$ taller than the one which was struck. This was in a far more exposed position, but it was not damaged in the least. The building was not damaged, neither was another tree of the same kind, of nearly the same height, and about twice its height distant, although it was far more exposed than the one which was struck. (2) Other than by mechanical tearing, the bark and sapwood suffered only minor and very local damage, although one side of the tree was blown to pieces, and the unsplintered portion of the trunk was split. (3) The splintering extended to only a little more than half the height of the tree; the split reached the same height, but did not extend to the ground. (4) Along the apex of the blaze, which was about 4 inches from the bark and not at the center of the tree, there was a column of fibers which were quite completely shredded. This column extended from the roots to a point above the top of the split; it closely followed the grain of the tree. At all places, except one, it was separated from the bark by unshredded wood. The one place where it communicated with the bark was on the upper side of a minor branch, 15 inches above the top of the split. There, very near the trunk, was a small hole where the wood had been blown outwards and

¹ For a detailed account of the observations, see *Monthly Weather Review*, November, 1925.

the bark blown off. From this hole, a small tuft of shredded wood was projecting; the hole had been blown so empty that, by means of a No. 26 copper wire, it could be probed to a depth of 4 inches. (5) Along one edge of the splintered section there were four small spots where the bark had been charred. At three of them the bark had been perforated. The wood, back of the highest and largest spot, was so completely splintered that little could be learned regarding the nature of the hole; it appeared to have been nearly horizontal. A short distance beneath the bark there was a column of shredded fibers, then a region of little or no shredding, and then the shredded fibers at the apex of the blaze. The next hole, about a foot lower, could be quite satisfactorily reconstructed from the material available. Shortly after entering the trunk, it was scarcely larger in section than the lead of an ordinary pencil. It extended 2 inches beyond the bark, was inclined to the vertical by about 50° , and lay very nearly in the plane bounding that side of the splintered section. The third hole, which was about a foot lower than the second, merely penetrated the bark; it seemed to be inclined to the vertical by about 28° , but, on account of its short length, it was not possible to determine the angle with certainty. (6) Only one large section was torn from the tree. This section bore several branches; not far from its center, it was broken and bent, and the fibers were crumpled and crushed in such a way as to show that the lower portion had been forced violently into the upper. This occurred before the section left the tree. Attached to the lower portion, was a branch which, within the trunk, had been broken squarely across the grain, and pulled from the trunk as a tendon might be pulled from a mortise. And this was done so nearly that the fibers were not bent and that a sliver (one inch wide, $\frac{1}{4}$ inch thick, and 4 inches long, which was split from the branch) was left attached to the trunk and undamaged. Two inches of this sliver projected free from the undamaged portion of the trunk and had been pulled out of the section bearing the limb. Such a break could have been produced only by a longitudinal tension which was quite closely parallel to the fibers in the plane of cleavage between the sliver and the branch. In passing up and around the branch, the fibers of the trunk bend outward at the sides of the branch and then inward to the point where they meet above the branch. Thus, above the branch and at a certain depth within the trunk, the fibers are almost perpendicular to the plane of cleavage between the sliver and the branch; and a little nearer to the surface the overhang is still greater, so that

they form almost an inverted cup. This branch lay just within the western boundary of the column of shredded fibers. A small part of the column passed to the west and the remainder to the east of the branch; the two portions reunited above the branch, where the fibers are inclined and cupped, as just described. The shredded fibers lay in the boundary between the torn out section and the standing trunk.

Even a casual observer would have noticed that the center of violence was not over 10 feet from the ground, and there seems no room for doubt that the main discharge which caused the damage passed through the charred spots, of which the largest and highest was only 8 ft. 3 in. from the ground. Situated as the tree was, it seems certain that, prior to the advent of the stroke, the local field at these points could not have been essentially greater than that at many neighboring points; and must have been far less than that at the top of the tree, and still less than that at the top of the tower, or at the top of the exposed trees mentioned.

Also, it is difficult to believe that the electrical strength of the air along the narrow paths leading to the holes differed from that elsewhere sufficiently to more than offset the reduced field at these lower levels. And surely the conductivity of the fibers which were shredded was not significantly greater than that of those surrounding them, and must have been appreciably less than that of the sap-wood, which was undamaged.

The widely accepted belief that the path of the flash coincides at each point either with the direction of the antecedent local field, or with the antecedent line of minimum electrical strength, or with a compromise between these two, appears to be entirely incompatible with these observations. In many ways, the observations suggest that we are here concerned, not with ordinary conduction, in which the carriers of the electricity drift slowly and follow the direction of the local field, but rather with a mighty rush of carriers—with something analogous to the well-known cathode stream.

And this is fully in accord with the observation made by Sir J. J. Thomson at the beginning of this century, that a spark does not occur until, at some point, the field is sufficiently intense to confer upon an electron, in the interval between its encounters with the molecules, a velocity sufficient to enable it to dislodge an electron from the molecule with which it collides. Then, if there were no mutual repulsion between the several free electrons, and if the positive residues were removed so rapidly as to keep the field constant, a swarm of electrons

would result. The swarm would be elongated in the direction of the field, and the number of electrons in the swarm would increase exponentially with the length of the path. After the first encounter there would be two electrons, after the tenth there would be over a thousand, after the 60th there would be over 10^{18} electrons; which represents a gross charge of over $1/8$ coulomb. For electrons moving with only a moderate velocity, 60 encounters will occur in a distance of about 40 microns. Owing to the mutual repulsion of the electrons, the swarm will tend to spread in all directions, but more especially in the direction of its motion; it will draw out into a dart. The leading electrons will be subjected to the repulsion of the trailing ones, as well as to the field arising from other causes, and hence their acceleration will be augmented. They will gain energy at the expense of the trailing electrons. Instead of a very great number of electrons moving at a moderate velocity, there will be a much smaller number moving with a correspondingly greater velocity. At velocities exceeding a certain value, the amount of energy an electron expends per unit length of path decreases as the velocity increases; consequently, at these velocities a weaker field will suffice to maintain the velocity. Once started with sufficient velocity, such a dart can continue to travel with unabated energy although the field is weak and, with a progressive reduction in energy, it can travel even in an opposing field. At high velocities, approaching that of light, the mutual fore-and-aft repulsion of the electrons is greatly reduced, and the effect of the attendant magnetic field (attraction of parallel currents) in great measure compensates the lateral repulsion. At these velocities the dart may be relatively compact. A high speed dart possesses a very considerable amount of momentum, and can strike a correspondingly powerful blow.

At low velocities, the path of a dart will coincide at each point quite closely with the direction of the local field existing antecedently to its arrival; as the velocity is increased, it will travel more and more under its own momentum, ignoring the local field. A high speed dart does not seek out a tree to strike, but merely collides with it. It makes no difference whether the tree is exposed or not; whether it is struck at the top or at the roots is merely a question of how it happens to be situated with reference to the path of the dart. True, the direction of the path just before collision will undoubtedly be modified by the presence of the tree, but the extent of the modification will be slight if the velocity of the dart is great. Where it collides, small

holes will be burned. Without other damage, the electrons will penetrate the trunk until their velocity is so reduced that they can become attached to the molecules composing the contents and walls of the cells; then their velocity abruptly decreases, and their progress becomes much more difficult. As their velocity is reduced, so is the magnetic field produced by their motion, and they are left more and more completely subjected to the full force of their mutual electrostatic repulsion, which urges them in all directions. In the particular tree studied, it appeared that the molecules were so crowded that they could not pass transversely to the grain without actually punching out the fibers ahead of them (as at the hole in the branch 15 inches above the split), but along the grain in the direction of the flow of the sap they could pass with a certain amount of freedom and in so passing the fibers were shredded. The longer the column over which the charged molecules are spread, the more pronouncedly longitudinal will be the resultant stress. If they can not pass across the grain, the tree will be splintered. The center of violence will be at the level of the entrance of the charge, and from this level the extent of the damage will decrease in both directions. In their passage up the fibers, in the case here considered, they encountered the overhanging fibers above the branch which was broken squarely across the grain, and which subjected them to a stress normal to their direction; this tore out the branch and drove upward the section of trunk containing it. Or, if it is preferred, we may say that a charge accumulated on these fibers, and was subjected to the repulsion of the charges which lay below them. Only a relatively small charge is needed to account for this damage. If there were only 1/600 coulomb on these fibers, and only twice as much at a point 30 cm. below it, the mutual repulsion would amount to more than the weight of 50 tons. This is more than ten times the longitudinal force required to tear apart a seasoned white oak rod having the same sectional area as the square break. Estimates of the amount of charge which could be involved in a lightning stroke run as high as tens and hundreds of coulombs, but what proportion of this is carried by the dart itself is not known.

If, while driving along the grain, the loaded electrons come sufficiently near the surface, the strength of the wood will be insufficient to stand the strain and the wood will be blown out and, through the opening so made, some of the shredded fibers will be ejected. Such was the case at the blow-out mentioned and also in the roots. Only

two of the latter showed damage, and in each case the center of damage was a single slender column of fibers. Where this came too near the surface a split occurred and the borders of the split were more or less shredded.

It seems that the observations which we have been considering can, on the basis of the present electron theory, be logically correlated with one another and with other well known facts by assuming that the stroke is initiated by a high speed dart of electrons. This delivers its entire charge practically at once, and is followed, along the ionized trail left by the dart, by a current of the usual type. This current will continue until there is such an equalization of potential that no more can flow, or until the negative carriers have become exhausted. If the conditions are such that at any point of the path, especially near the cloud, the field is sufficient to impart to the positive residues a velocity which enables them to dislodge electrons by collision, there will be a continuing supply of electrons until that condition ceases to exist.

Scattered throughout the atmosphere, below the cloud as well as in and above it, are regions in which the atmosphere is electrically charged; some are charged positively, others negatively. All are drifting under the action of the electric field, and are being carried hither and thither by the wind. Between two such regions, oppositely charged and suitably placed, the electrical field will be much greater than if these regions were uncharged. In such a place the dart may originate and acquire the velocity requisite for its continuance in the weaker, undisturbed field. The intensity of the field required to produce a dart depends in some measure upon the velocity with which the electron enters the field.

The dart which we have been considering traveled towards the ground. Obviously, under other conditions, a dart might originate at the ground and travel in the reverse direction. It would originate where the field is intense, as at the top of an elevated object. The dart itself would do no damage; the damage, if any, would arise from the current of positive residues. Like other charged gas molecules, these move relatively slowly and possess but little momentum, but on account of their great number they may convey a great current. They will not penetrate deeply into the trunk of a tree, but will pass mainly along the well conducting sap-wood, that will bear the brunt of the damage. Lightning strokes possessing these characteristics are well known.

In neither case is the stroke the result of the cloud discharging to earth, though the cloud does become discharged as a result of the

stroke. That, however, is purely an incidental and a subsequent effect. The negative charge of the dart is assembled along the path; the remainder of the charge involved in the stroke comes from the ionization produced by the dart. The charges in the cloud are, probably in large part, neutralized *in situ*, either by the spreading of the delivered charge by its own mutual repulsion, or by the dissemination of the ions by the wind. It is distinctly an after effect of the spark.

Such seems to be the essential nature of a lightning stroke. There is first a rush of electrons, which blazes the path, then, along this conducting path, flows a more leisurely conduction current of the usual type. Under certain conditions, perhaps usually, this conduction current will convey a far larger quantity of electricity than is carried by the dart of electrons. The direction in which the dart flies is in a very real sense the direction of the stroke—the direction in which it is delivered. The effects produced where the stroke starts differ quite characteristically from those produced where it ends.

PHOTOGRAPHY.—*Photography for the field geologist.* ELIOT BLACKWELDER. Stanford University.

GENERAL

Nearly every field geologist carries a camera; but it is a common experience at the end of the season to find that pictures taken of some of the most important subjects were failures and that a much larger number were neither as distinct nor as bright as they should have been. This is due to the fact that the taking of good photographs under all sorts of conditions is an art understood by but few users of the camera. Success in it requires a comprehension of certain facts and principles and close attention to the necessary details. The accuracy of photographs as records of field conditions makes them a valuable supplement to the usual notes, maps and sketches; and therefore it is advisable for every geologist to inform himself to such an extent that he may be able to take good photographs under nearly all possible conditions. As a result of some twenty-five years of more or less painful efforts to reach such proficiency, the writer ventures to offer the younger geologist a few suggestions that may improve his results. In general the difficulties are not the same as those which confront the professional studio photographer, and so these remarks apply more particularly to field work.¹

¹ A paper of interest in this connection is *Stereoscopic Photography in Geological Field Work*, by F. E. Wright. This JOURNAL 14: 63-72. 1924.

EQUIPMENT

Good results should not be expected without good equipment. The small pocket camera is not capable of giving photographs of much use to the geologist, except for nearby objects under favorable light conditions. Therefore he will do well to provide himself with a more elaborate camera, equipped with a ground glass for focussing, and as large as he can reasonably carry. The 5×7 inch size is one of the most satisfactory, but in some kinds of work a smaller camera may be all that circumstances permit.

One of the most important things is to get the best convertible lens and shutter that can be obtained. After trying various lenses, the writer finds that the Goertz Dagor type gives the sharpest detail; but some prefer other convertible lenses, such as the Zeiss Protar or Tessar, the Bausch and Lomb, or the Cooke lenses. One of the best shutters is the Compound; but there are others in the same class. It is advisable to have a lens consisting of two elements, one of which can be removed to permit using a long focus for telephoto views. For this purpose it is necessary that the camera have a rather long bellows.

To record the picture one now has considerable range of choice. Glass plates are perhaps the best means, but their fragility and weight are serious disadvantages in the field. Fortunately, cut films, which are free from such defects, give almost equally good results. Roll-films and film-packs are distinctly inferior on account of their slight tendency to curvature, so that they seldom give as sharp images as plates. Nevertheless, they are tempting because of their greater convenience, and they may well be used for photographs of minor import or those in which minute detail is not required.

Various kinds of cut films may now be obtained for different purposes. For moving objects, or for taking views from trains or from windy stations, rapid films, such as Eastman "Portrait Super-Speed" film, may be required; but the results are usually not as good as those obtained with slower films. For general work within one or two miles of the camera, and where it is not important to bring out the more unusual colors, Eastman "Commercial Ortho" and other equivalent films are satisfactory. For distant mountain pictures with more or less blue haze, or for any pictures in which colors need to be especially differentiated, the writer finds nothing equal to "Panchromatic" films. In fact, he has found nothing else that will give even tolerably satisfactory results in photographing desert mountain scenery,

where the blue haze is nearly always in evidence. The only disadvantages to using Panchromatic films are their slightly greater cost, and the fact that they must be loaded and developed in darkness.

Ray-filters, or color screens, are indispensable for many geologic photographs. It is best to carry several kinds for different purposes. The function of the ray-filter is to equalize the rays of various photic intensities and thus to give truer color-values. A suitable filter is particularly important for the purpose of counteracting the effects of the blue and violet rays which predominate in the light coming from distant mountains. In photographing ordinary landscapes with Commercial Ortho films, the author has found the Wratten *K-1* filter (made by the Eastman Kodak Company) satisfactory. When using Panchromatic films on distant mountains or desert scenes, best results have been obtained with the *G* filter of the same series,—a rather deep orange-colored glass. Even better results are given by using a red filter, but this requires about five times as much exposure, and that is a serious disadvantage when the wind is blowing. Various smaller ray-filters for pocket cameras are on the market.

Sharp definition of the details in a photograph depends partly upon accurate focussing of the lens and partly upon the stability of the camera. If a scale is used for focussing, it is advisable to test the scale carefully before going into the field, and it is also necessary for the operator to be sure of the distance to be covered in each photograph. In general, it is probably best to focus on the ground glass every time, and for this purpose it is desirable to carry a black cloth to shut out the light.

Beginners seldom realize the importance of stability of the camera. It is true that very rapid exposures, such as $\frac{1}{125}$ of a second, may be taken from a moving train or when a violent wind is blowing; but ordinary snapshots, even with an exposure of $\frac{1}{8}$ of a second, generally show the effects of slight movement. With the slower films and ray-filters, it is necessary to use a solid support, such as a tripod. While the ordinary tubular metal tripod is better than none, and may be satisfactory in calm weather, it is not stable enough for ordinary conditions. It is much better to use a fairly heavy wooden tripod of the type that can be folded into a small space.

It is now possible to obtain for the tripod head a ball-and-socket joint attachment that facilitates the photographing of objects on the ground or in other awkward positions. However, for a heavy camera it may be necessary to have such an attachment specially reinforced

to overcome vibration. Still better, one can use the tilting tops that are now obtainable; they are screwed on the top of the usual tripod.

One of the most important problems confronting the photographer is that of the length of exposure to be given when taking the picture. Since this varies with the latitude, altitude, sky conditions, climate, nature of subject, time of year, hour of day, distance from subject, shadows, etc., it is really a very complex problem. To facilitate the necessary calculations, it is almost essential to use some kind of exposure meter. Of these there are now many types on the market. The writer has obtained best results with the Harrold exposure meter, and finds it compact, durable, and easy to operate. Only the most experienced photographer can afford to depend upon judgment or memory, when it comes to estimating the length of exposure required in a given case, except where all of the various conditions are what may be called normal.

TAKING THE PICTURE

It is well to remember that the camera is not capable of giving everything that the human eye can see. In order to show topographic details, the light must be favorable. Since it is the small shadows that bring these details into prominence, it is best to take the picture from such a position that the sun's rays are nearly at right angles to the line of sight. For the same reason, photographs taken within two hours of sunrise or sunset show the greatest detail in mountain slopes, because the shadows are longer then than at noon.

Timing the exposure is perhaps the most acute problem at the moment of taking the picture. Exposure meters are usually devised for the conditions which prevail in the populous part of the eastern United States. For other regions certain allowances must be made. For example, in the western plateaus and mountains, at elevations of about 5000 feet, it is found necessary to reduce the time to one-half that which is indicated by the exposure meter. Above 10,000 feet, it should be reduced to one-third. On the deserts of the southwestern states, similar reductions should be made at much lower altitudes,—2000 and 6000 feet respectively. Few people realize how important the factor of distance is, in this respect. At a distance of 2 to 3 miles, the time should be further reduced about 10 per cent; and for 25 or more miles, about 50 per cent, as compared with nearby objects. It is often impracticable to obtain a good image of both the near and the distant objects; but suitable films and ray-filters, with carefully calcu-

lated exposures, will give fair results that are impossible without them.

In order to photograph very light-colored objects, such as desert plains, quartzite outcrops, sand dunes, snowy peaks, and lakes, it is necessary further to reduce the time of exposure by 25 per cent to 75 per cent, according to the degree of reflection of light from the surface in question. One must acquire by experience an intuitive perception of the light-reflecting properties of the various subjects to be photographed.

There is another correction which is nearly always overlooked, but which is rather important when taking photographs at early or late hours in certain parts of the country. It should be remembered that the exposure-meter has been designed for correct time, i.e., solar time, but that our watches generally give "standard time." It therefore happens that if one is situated near the boundary between two standard time zones, his watch is in error as much as half an hour with reference to solar time.

In order to obtain contrast in the larger outlines of the picture, it is better to under-expose the film a little. On the other hand, to obtain detail in smaller objects, especially within a few feet of the camera, it is better to over-expose somewhat. For example, a dissected mountain slope some miles away would show best in the former case, and a rock specimen photographed in the laboratory would need the latter.

FINISHING THE FILMS

Developing and printing are important operations. They should be performed only by experts who are instructed in advance regarding the general nature of the photographs that have been taken and the kind of negatives especially desired. It is unwise to entrust such matters to the ordinary drug-store agency, or even to the average town photographer. It is best to seek out a qualified, experienced photographer, explain one's problem to him, and then send him all the films, even though it sometimes involves more or less delay. It is especially important never to let a careless or inexperienced person either load or develop the highly sensitive Panchromatic films.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY

927TH MEETING

The 927th meeting was held in the auditorium of the Cosmos Club on Saturday evening, November 28, 1925. The meeting was called to order by President FLEMING at 8:15 with 46 persons in attendance.

Program: G. BREIT and M. A. TUVE. *Radio evidence of the existence of the Kennelly-Heaviside Layer.* (Presented by Mr. BREIT and illustrated with lantern slides.) A method of testing for the existence of the Kennelly-Heaviside Layer has been described by the authors (see *Journal Terrestrial Magnetism and Atmospheric Electricity*, March, 1925). This method has given a definite indication of the existence of the layer. The transmission took place from Bellevue, Anacostia, as well as other stations. The layer is found to have different reflecting powers for different wave-lengths. Its properties change rapidly with time. Frequently it is capable of sending down more than one wave. This appears to be especially true in the afternoon and at night. The effective height of the layer is not quite constant but varies. It is generally in the neighborhood of 100 miles. The wave returned from the layer is differently polarized from the wave traveling along the ground.

Discussion. The paper was discussed by Messrs. WHITE, HUND, LAPORTE, BAUER, GISH, CURTIS, MOHLER and WENNER.

V. E. WHITMAN. *Studies in the electrification of dust clouds.* (Illustrated with lantern slides.) Dust clouds were formed by blowing various pure chemical substances through tubes and the net electric charge imparted determined as a function of the composition of the dust, tube material, area of contact between the dust and the tube in being blown out of the tube, velocity with which the dust moves through the tube, and the length of the path of the dust through the tube. An apparatus was described with which photographic records of the paths of particles are obtained. Such photographs show the presence of positive, negative, and neutral particles in all dust clouds, even of very pure substances. The ratio of positive to negative electrification in a cloud is found to change as the larger particles in the cloud settle out, but evidence is obtained which contradicts the hypothesis that the large particles carry an opposite charge from the small particles in a given cloud. The paper closed with a few remarks bearing on the relation of the present experimental data to the concept of a tribo-electric series. (*Author's abstract.*)

Discussion. The paper was discussed by Messrs. DRYDEN, TUCKERMAN and SILSBEE.

928TH MEETING

The 928th meeting, constituting the 55th annual meeting, was held in the Cosmos Club auditorium Saturday, December 12, 1925. It was called to order by Vice-President AULT at 8:16, with 37 persons present.

The report of the Treasurer showed total receipts, \$3328.44; disbursements, \$2974.70, leaving a balance of \$353.74. The report of the secretaries showed that 18 meetings were held during the year, several in conjunction with other societies.

The following officers were elected for the ensuing year: *President*, WILLIAM

BOWIE; Vice-Presidents, J. P. AULT and PAUL R. HEYL; Treasurer, W. D. LAMBERT; Corresponding Secretary, H. L. DRYDEN; Members-at-Large, General Committee, G. BREIT and E. W. WOOLARD.

At the conclusion of the business meeting Dr. WILLIAM H. DALL addressed the Society on *Some recollections of the founding of the Philosophical Society*. The address was highly appreciated, the presiding officer voiced the sentiments of all present in thanking Dr. DALL for his address. Following Dr. DALL's address Prof. JAMES H. GORE and Dr. WILLIAM H. HOLMES also spoke on the early days of the Philosophical Society.

H. A. MARMER, *Recording Secretary*.

THE BIOLOGICAL SOCIETY

681ST MEETING

The 681st meeting of the Biological Society was held in the assembly hall of the Cosmos Club, October 24, 1925, at 8 p.m., with President ROHWER in the chair and 51 persons present. W. F. RUBEN, Geological Survey, was elected to membership.

VERNON BAILEY described the effects of fire in destroying muskrats in marshes in Louisiana. Many muskrat houses are burned and dozens of the animals are sometimes found dead. In places where extensive fires occur, it is estimated that thousands of muskrats may be killed.

J. N. ROSE reported that plans are being made for a 5,000 acre arboretum with a prospective endowment of \$20,000,000 near Los Angeles, California.

A. A. DOOLITTLE described examining a cat found in poor condition. It proved to be heavily infested with tape worms of a species usually met with in man.

S. A. ROHWER announced the recent death of a member, Dr. W. D. HUNTER of the Bureau of Entomology, in El Paso, Texas. Dr. HUNTER, who had been in charge of important work in Texas for some years, was formerly active in entomological and other biological work in Washington.

P. B. JOHNSON referred to observations on viscachas recently living in the National Zoological Park. After a heavy rain a young one of a more bluish color than older animals was seen nestling close against the body of an adult male, presumably for warmth.

VERNON BAILEY, Biological Survey: *Two years' progress in beaver farming*.—Two beaver colonies established in 1923 in northern Michigan, where the animals are thriving and increasing in a satisfactory manner, were described. From one fully enclosed area one of the beavers escaped by digging under the fence when their dam raised the water above the bottom wires, but in a short time returned and was admitted to the inclosure with its companions. In the other colony, where only a drift fence had been built across the creek below them, a few of the beavers had crossed to the head of a neighboring creek and a second colony was established. This can be controlled by another short section of fence across the creek and meadow below. Both colonies are in excellent location for beaver farms.

The importance of feeding beaver when the food supply near the shores is exhausted was emphasized and lantern slides of some of those caught in Mr. Bailey's improved beaver trap were shown. (*Author's abstract.*)

AGNES CHASE, Bureau of Plant Industry: *Hunting grasses in Brazil*.—The speaker spent 7 months in Brazil, visiting the states of Pernambuco, Alagoas, Bahia, Rio de Janeiro, Minas Geraes, and São Paulo. The sertão

of both Pernambuco and Bahia was badly overgrazed. A trip was made to Paulo Alfonso Falls in Rio São Francisco. The falls, which are 81 meters high in all, form a stupendous cascade, not a straight fall. The region is a rocky desert with very little vegetation. In January Mrs. Chase botanized in the region about Rio de Janeiro and with a party from the Jardim Botânico visited Itatiaia, the peak of which, Agulhas Negras, was until recently believed to be the highest point in Brazil. Its altitude is now in dispute. On the ascent through tropical jungle a group of monkeys was seen. Above timber line grasses were abundant. About three months were spent in Minas Geraes, the highland campos of this state being especially rich in grasses. Serra de Cipó, 150 kilometers northwest of Belo Horizonte, yielded the best results of the entire trip. Three weeks were spent in the vicinity of Viçosa in the eastern part of Minas Geraes, where Dr. P. H. Rolfs is building up a school of agriculture for the state. With Dr. Rolfs and his daughter a trip was made to Serra da Gramma, and later with Miss Rolfs to Serra de Caparaó. The highest peak of this range, Pico de Bandeira, 2884 meters, disputes with Agulhas Negras the place for highest point in Brazil. The party ascended Pontão Crystal, 2798 meters, instead of Pico de Bandeira, 2884 meters in altitude, but the botanical results were probably as good as if the higher peak had been attained. A last trip into highland campos was made to Campos de Jordão, São Paulo. (*Author's abstract.*)

682D MEETING

The 682d meeting was held in the assembly hall of the Cosmos Club, November 7, 1925, at 8:05 P.M., with President ROHWER in the chair and 59 persons present. FRANK THONE, Science Service, Washington, D. C., J. K. STRECKER, Baylor University, Waco, Tex., and GEORGE M. LIND, Fort Collins, Colo., were elected to membership.

H. C. OBERHOLSER referred to the establishment of the Upper Mississippi River Wild Life and Fish Refuge by Act of Congress providing for the purchase of over 300,000 acres of overflowed lands along the Mississippi River from Rock Island, Ill., to Wabasha, Minn. A sum of \$1,500,000 has been set aside, a part of which is now available for the acquisition of lands by the U. S. Department of Agriculture through the Biological Survey, which in cooperation with the Bureau of Fisheries will administer the area. Attention was directed to the high value of this great refuge, the object of which is to conserve recreational and economic resources in the interest of all the people.

VERNON BAILEY mentioned seeing a woodchuck near Washington and requested that members report any similar observations, with dates, with a view to securing more definite information relative to the length of the hibernation period of this animal in the District of Columbia.

F. C. LINCOLN reported seeing a woodchuck about a month ago near White's Ferry, Va. Its actions were unusual as it came running down the road and passed close between him and a companion before finally turning off into the brush.

L. O. HOWARD, Bureau of Entomology: *Something about the salt marsh mosquito problem.*—The speaker described the biology of the most prominent salt-water mosquitoes, namely *Culex sollicitans* and *Culex taeniorhynchus*, showing that in spite of his own efforts to learn the life histories of these species, they were not understood until a very thorough investigation had been made by the late Dr. John B. Smith, State Entomologist of New Jersey (and former Secretary of the Biological Society of Washington), and his

associates in 1902. He then spoke of the extraordinary work that has been done by the State of New Jersey along its whole ocean front in draining and diking the marshes so as to prevent the breeding of those mosquitoes which were for years the dominant mosquitoes of New Jersey and which had given that State its mosquito reputation. Both forms fly for great distances, and in the summer may be found 40 miles from the coast.

The speaker mentioned other salt-marsh work which had been done on Staten Island, in Connecticut and, to a slight extent, in Florida; and then proceeded to tell about the great scourge of mosquitoes along the Gulf coast of Louisiana, Mississippi, and Alabama during the past season, which had aroused great excitement among the owners of property in these regions and had caused them to organize a survey of mosquito conditions which eventually may bring about a large-scale effort to drain the marsh breeding places. The speaker pointed out that this would be an enormous undertaking. He showed that, of the approximately 12,000 square miles of salt marsh on the whole of the Atlantic, Gulf and Pacific coasts of the United States, more than 6,000 square miles are included in the State of Louisiana. Complete and successful work will probably cost an enormous sum of money, but the value of the reclaimed land, to say nothing of the abatement of the mosquito scourge, will undoubtedly make such work well worth while. (*Author's abstract.*)

E. A. GOLDMAN, Biological Survey. *Over-browsing by Kaibab deer.*—The deer inhabit the Kaibab Plateau on the north side of the Grand Canyon of the Colorado River, embracing an area set aside as the Grand Canyon National Game Preserve in 1906, and a part of the territory now included in Grand Canyon National Park. There is little migration from the area and, under protection from hunters and partial protection from predatory animals, the deer have increased to numbers estimated by some at more than 30,000. The forage producing capacity of the area is being progressively reduced by over-browsing until it has reached a point where many deer are threatened with starvation.

In addition to the wide-spread destruction of shrubs favored by deer, forest trees, especially reproduction of aspen, yellow pine, pinyon, white fir, spruce and juniper are being seriously injured or killed. The critical situation that has arisen emphasizes the importance of regulating the numbers of game on limited areas in accordance with the forage supply, as a general conservation measure. The Grand Canyon National Game Preserve, with boundaries nearly identical with those of the Kaibab National Forest is under the administrative control of the Forest Service which is seeking a solution of the many-sided problem. (*Author's abstract.*)

683D MEETING

The 683d meeting of the Society was held in the assembly hall of the Cosmos Club November 21, 1925 at 8:05 P.M., with President ROHWER in the chair and 120 persons present. Dr. F. H. CHITTENDEN and Miss MABEL COLCORD were elected to membership.

T. S. PALMER, Biological Survey: *Report on the recent meeting of the American Ornithologists' Union, New York.*—The speaker gave an account of the annual meeting of the American Ornithologists' Union held in New York City in November, referring especially to the exhibition of the bird paintings and to the widespread membership of the Union. Mention was made of the next meeting of the Union, to be held in Ottawa, which will be the first meeting held outside the United States.

W. C. HENDERSON, Biological Survey. *When the elk come down.*—Of the two large herds of elk now in existence in the United States, the principal herd is that in the Jackson Hole region in Wyoming. Under the protection afforded it, the herd is increasing rapidly in numbers and to such an extent that the greatest problem connected with its preservation is that of providing sufficient food in winter. The only solution that seems practicable is that of keeping down the numbers by more extensive hunting in the open season. The speaker showed slides illustrating the herd and in conclusion gave a moving picture film, prepared by the Biological Survey, showing the way in which elk are killed by poachers for the sake of the teeth.

H. C. OBERHOLSER, Biological Survey: *Birds on the Farallon Islands, California.*—The speaker described the islands and showed moving pictures illustrating the murres, guillemots, cormorants, gulls, and petrels, which make up the bird life. The most abundant birds are the murres, whose numbers are estimated at about 20,000.

H. C. OBERHOLSER: *The bird reservations of Louisiana.*—The speaker showed films illustrating the bird refuges on small sandy islands off the coast of Louisiana, which are populated principally by laughing gulls and royal terns, together with a much smaller number of shore birds, such as willets.

684TH MEETING

The 684th regular meeting of the Biological Society was held in the assembly hall of the Cosmos Club December 5, 1925, at 8:05 P.M., with President ROHWER in the chair and 48 persons present. Dr. D. N. SHOEMAKER was elected to membership.

L. D. MINER reported the observation of a black-billed cuckoo feeding on caterpillars along the canal in the vicinity of Washington on 28 October.

A. S. HITCHCOCK spoke of the close relationship between the floras of the northeastern United States and northeastern Asia and added another to the already long list of identities in the two floras, *Brachyelytrum erectum*. This is a common grass in the northeastern United States, and was recently found by him in a collection sent from China.

W. B. GREELEY, Forest Service: *The proposed changes in the boundaries of Yellowstone National Park in relation to wild life* (illustrated).—The speaker discussed the existent National Forests and National Parks with special reference to the proposed enlargement of the boundaries of Yellowstone National Park to include the rest of the Yellowstone River basin, most of the Grand Tetons, and the winter range of the Jackson Hole elk herd. With the other members of the coordinating committee appointed at the recent Conference on Outdoor Recreation called by President Coolidge, he made a trip through the area during the past summer. The paradise of wild life found in the vicinity of Bridger Lake was described, with illustrations of the scenery and of the bear, elk, moose, mule deer, bighorn, and other large mammals. The problem of providing winter food for the Jackson Hole elk herd still awaits solution. The speaker proposed the restriction of the herd by hunting to about 15,000 as the only way to prevent the starvation of large numbers of elk in bad winters. The additions proposed to Yellowstone Park follow natural drainage lines instead of the present artificial boundaries, and small additions on the northwest and northeast sides and a larger one on the southeast, with some restriction of boundary on other sides. The coordinating committee has recommended that the Grand Tetons area be preserved in a completely wild state as a National Park.

The paper was discussed by S. T. MATHER, who accompanied Col. GREELEY as a member of the coordinating committee. He reported that the Hopi Ranch north of the Yellowstone had recently been purchased from a privately raised fund and will be used as a shelter for antelope in winter.

T. H. KEARNEY, Bureau of Plant Industry: *Pollination in cotton* (illustrated).—Cotton plants are adapted for both close and cross-fertilization. Close fertilization is desired by plant breeders to preserve the purity of selected strains, and insect pollination must be prevented. Experiments show that insect pollination is much more effective at Sacaton than near Phoenix, Arizona, owing to the greater comparative abundance of insects, especially honey bees. Few natural hybrids occur, even if both Egyptian and upland cotton are grown close together, owing to the fact that the bulk of the pollen grains on the stigmas are found to be self pollen. Selective fertilization—the greater effectiveness of like pollen than of an equal amount of unlike—also tends to prevent the formation of hybrids. Hybrids in the F_1 generation are uniform and intermediate in most characters, but in F_2 the characters break up badly. Strict inbreeding for seven generations has produced no bad effect.

685TH MEETING

The 685th regular and 46th annual meeting was held in the lecture hall of the Cosmos Club December 19, 1925, at 8 P.M., with President ROHWER in the chair and 24 persons present. The minutes of the previous Annual Meeting were read and approved. New members elected. C. DENLEY, G. B. GRANT, O. J. MURIE.

The annual reports of the Corresponding Secretary, the Recording Secretary, the Treasurer, and the Publication Committee were read and ordered placed on file. T. S. PALMER, for the Board of Investing Trustees, presented an informal report showing that the George Washington Memorial Fund amounts to \$600, that there is about \$1500 in the Publication Fund, and the sum of \$430 is due the Publication Fund from the General Fund. F. C. LINCOLN gave a sketch of the history of the George Washington Memorial Fund.

The election of officers then took place, resulting as follows:

President, H. C. OBERHOLSER, *Vice-Presidents*, E. A. GOLDMAN, A. WETMORE, C. E. CHAMBLISS, H. H. T. JACKSON; *Recording Secretary*, S. F. BLAKE; *Corresponding Secretary*, T. E. SNYDER, *Treasurer*, F. C. LINCOLN, *Members of Council*, H. C. FULLER, W. R. MAXON, C. W. STILES, A. A. DOOLITTLE, B. H. SWALES. President-elect H. C. OBERHOLSER was nominated as a Vice-President of the Washington Academy of Sciences to represent the Biological Society. On motion of Dr. STILES a rising vote of thanks was given S. A. ROHWER for his efficient service in the presidential chair.

ENTOMOLOGICAL SOCIETY

376TH MEETING

The 376th meeting was held in Room 43 of the New National Museum, Thursday, June 4, 1925, with President R. A. CUSHMAN in the chair and 17 persons present. THOMAS R. CHAMBERLAIN of the Bureau of Entomology, Salt Lake City, Utah, was elected to membership.

Program: C. H. RICHARDSON: *Some aspects of insect physiology*.—Certain aspects of physiology as applied to insects were presented briefly. General physiology has suffered a one-sided development largely because the higher

vertebrates, particularly man, have been the subjects of most of the investigations. Digestion in insects was compared with that in the vertebrates, and with a few exceptions was shown to present no unusual features. Absorption from the alimentary tract and from the malpighian tubules was discussed and the need for more studies on permeability was emphasized. A discussion of the nutritive requirements of insects concluded the paper. It was discussed by Dr. McINDOO.

C. HEINRICH: *Comments on the distribution of the European pine-shoot moth.* A trip was recently made through New Jersey, New York, Connecticut, Massachusetts, and Rhode Island to determine the present status of the European pine-shoot moth (*Rhyacionia buoliana* Schifferrmüller). The situation today is about what it was in 1914 except that on Long Island a greater area is infested, *R. buoliana* having appeared in many new localities and on a number of private estates that were uninfested in 1914. The species was also found in Tarrytown, N. Y., and at Newport and on the Duke estate at Somerville, N. J., but in several other places where it had been found in 1914 it was no longer present. In Tarrytown and Somerville and in the nurseries at Newport it was considerably less abundant than formerly, owing to efforts by nurserymen and gardeners to eradicate the insect. In a few localities about Boston and in Connecticut where it had been located in 1914 it was not found on the recent trip. The situation was summarized as follows: *R. buoliana* has been able to survive local conditions and to thrive in this country for something like thirteen or fourteen years. It is established and well distributed on Long Island, which will remain, as long as the insect is there, a source of infestation for other places. It is also well established, though not so widespread, in Newport and vicinity, and it has been distributed from nurseries to various private estates in New York, Connecticut, Rhode Island, New Jersey and probably in other localities further west. Attempts have been made by nurserymen and gardeners to eradicate the pest in their localities by cutting buds, but this work, though conscientious, has not been under the supervision of an entomologist and has not been thorough. Consequently the moth has persisted in most of the localities where it has been introduced. In places where the clean-up has been thorough (at points in Massachusetts and at Great Neck, L. I.) the insect has completely disappeared. It has apparently not escaped into any of our forests or into large plantings or standing growths of native pines. The advisability of eradicating this moth from the United States before it becomes a forest problem was urged. The paper was discussed by Messrs. ALDRICH, BAKER, BÖVING, GRAF, and McINDOO.

Dr. BÖVING exhibited a recent book from Denmark, which contained numerous fine pictures of the pine-moth work in Denmark.

R. A. CUSHMAN: *Some parasites of the pine-tip moth.*—Parasites reared from the pine-tip moth, *Rhyacionia frustrana* Comstock, were considered in connection with a projected attempt to colonize them in the Nebraska National Forest, where the host has caused great havoc in the young pine. The habits of the various species in relation to the host and their relative abundance and effectiveness were discussed. The paper was discussed by Messrs. BAKER, CRAIGHEAD, HEINRICH, RICHARDSON and ROHWER.

377TH MEETING

The 377th meeting was held in Room 43 of the New National Museum, Thursday October 1, 1925, with President R. A. CUSHMAN in the chair and 38 members and 14 visitors present.

Mr. CUSHMAN announced that since the last meeting the Society had lost by death, Dr. B. H. RANSOM, who passed away September 17, 1925. A committee composed of Dr. M. C. HALL, Dr. H. E. EWING, and Mr. S. A. ROHWER drew up the following resolution which was read and adopted by the Society:

Resolution: Dr. BRAYTON HOWARD RANSOM, Chief of the Zoological Division of the Federal Bureau of Animal Industry and for many years a member of the Entomological Society of Washington, died September 17, 1925, at the age of forty-six years. In his investigations in the broad field of animal parasitology, Dr. RANSOM made frequent contributions to the subject of medical and veterinary entomology. His publications which have a direct bearing on entomology include a wide range of subjects, such as habits and biology of the Texas fever tick; arsenical dips for ticks; eradication methods for ticks; a nematode parasite of the house fly and certain dung beetles, miscellaneous cattle parasites; and sheep scabics. Perhaps his most comprehensive paper on insects is that published in Pierce's "Sanitary Entomology." This paper deals with the relation of insects to the parasitic worms of vertebrates. The studies of arsenical dipping for the control of ticks conducted by Dr. RANSOM and his collaborator, H. W. GRAYBILL, are basic investigations of great economic importance. Dr. RANSOM was a man of great modesty and personal charm, a delightful friend and companion and a man of sound judgment and conservative ideas. His advice and counsel were highly prized by his associates and collaborators. His death at such an early age is a loss to science and his friends. The Entomological Society of Washington regrets the loss of this active worker and wishes to record its sincere appreciation of the man and the scientist.

W. H. LARIMER of the Bureau of Entomology, Washington, D. C., was elected to membership.

Program: Dr. L. O. HOWARD. *The Third International Congress of Entomology at Zurich.*—The speaker described briefly the principal features of the congress held at Zurich, July 19 to July 26, 1925, and showed on the screen portraits of forty or more of the principal delegates from different countries, reproduced from photographs taken by himself at Zurich.

Dr. J. B. PARKER: *Some notes on the nesting habits of Bembix comata* Parker. —This paper has been published in full in PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON (27: 189-195. 1925).

Dr. WILLIAM BARNES of Decatur, Illinois, spoke briefly about his trip abroad.

Dr. E. A. BACK spoke of a soap spray for *Aleyrodidae*, stating that enough of the oil remained on the leaves to kill the eggs. He also spoke of a new process for spraying raisins that is used at Fresno, California. If successful, it will be of greater value than the old methods.

Dr. T. E. SNYDER gave the following note on *Mastotermes darwiniensis* Froggatt: Dr. GERALD HILL of Australia, one of the active British students of termites has recently discovered that *Mastotermes darwiniensis* Froggatt, the primitive Australian termite, lays its eggs in a mass similar to that of the *Blattids*; this mass is approximately 5 mm. in length and consists of two parallel rows of eggs cemented together; 14 to 24 eggs to a mass.

In the *Blattids*, Mantids and *Mastotermes*, Crampton had found that the seventh sternite in the female was prolonged and that this covered the ovipositor. The roach-like wings of *Mastotermes*, the large anal area, and this egg mass, similar to an oothecum, further establishes the relationship of termites to the ancient roaches. Three fossil species of *Mastotermes* have been

found in England, one in the Upper Eocene and two in the Middle Oligocene. A primitive South African genus of termites has recently been discovered as a fossil in the Rott of Germany.

378TH MEETING

The 378th meeting was held in room 43 of the New National Museum, Thursday, November 5, 1925, with President R. A. CUSHMAN in the chair and 30 members and 13 visitors present.

MR. CUSHMAN announced the death of Dr. W. D. HUNTER, which occurred October 13, 1925, at El Paso, Texas.

A committee composed of Messrs. C. L. MARLATT, F. C. BISHOP, A. BUSCK, and Dr. L. O. HOWARD, chairman, drew up the following resolution:

Resolution: The announcement of the death of Dr. WALTER DAVID HUNTER has caused the members of the Entomological Society of Washington to sorrow very deeply. Although seldom present at our meetings of late years, Doctor HUNTER was the dear friend of many of us, and all of us respected him and admired him for his notable achievements in applied entomology. We realize that by his work and his sound judgment and by his high character as a man he had gained the confidence of the people, especially of the South, to an unparalleled degree. We realize further that he has had a most important influence in the awakening of a realization of the very great value of entomological work. No memorial could express adequately the value of his life work, and we can only grieve with others that blind fate should have stopped it in mid-career. The Society authorizes the preparation of a biographical account of Dr. HUNTER, and its publication together with his bibliography in the PROCEEDINGS OF THE SOCIETY.

This resolution was adopted.

Program: Dr. A. G. BÖVING *Entomological collections in the museums of Denmark and Sweden.*—The speaker explained the educational training required for the attainment of the scientific positions in the Scandinavian museums, and mentioned the salaries, working hours and holidays that go with these positions. Rather detailed information was given concerning the arrangement and the contents of the entomological main collection in the Copenhagen Museum and on the origin and history of its most valuable special parts. Biographical remarks were added on the two famous Danish entomologists, FABRICIUS and SCHIODT, the latter a most enthusiastic and successful collector and observer in the field. The personalities and scientific contributions of some of the now living Danish entomologists were sketched.

Dr. STEPAN SOUBEK, Assistant, Zoological Institute of the College of Agriculture and Forestry at Brno, Czechoslovakia, spoke briefly to the SOCIETY.

Dr. J. BEQUAERT of the Harvard School of Tropical Medicine spoke briefly on the *Tabanidae* or horse flies as disease carriers.

A. T. GAHAN reported two interesting records of little known parasitic *Hymenoptera*. The material was received from GUY A. K. MARSHALL, Director of the Imperial Bureau of Entomology, London, England. There were four males of *Paracarotomus cephalotes* Ashmead reared from a pupa of *Paragus* sp. at Ibadan, South Nigeria, by O. B. Lean, and *Telenomus nawaii* Ashmead reared from eggs of *Prodenia litura* at Levuka, Fiji.

Dr. J. M. ALDRICH spoke of the high prices charged for the German scientific publications, especially those in "Archiv. für Naturgeschichte."

Mr. SHANNON made a few remarks regarding the use of the name "insect" in which he referred to his proposal made at the 373d meeting to apply this

name to all Arthropods exclusive of the Crustacea. He read from a recently published book on medical entomology by Dr. CARROLL FOX, "Insects and Diseases of Man," the definition given for medical entomology: "Entomology is that part of zoology which treats of insects. . . . It is generally agreed that the term medical entomology may include acarines or other arthropods which have been implicated in the occurrence or spread of disease." This shows that the medical entomologist at least finds it convenient to use the name "insect" as was proposed by the speaker.

Mr. ROHWER told of receiving a specimen of *Tiphia punctata* Robertson which had been collected by HAROLD E. BOX two miles south of Santiago in the Dominican Republic. He stated that this was the first record of this species of *Tiphia* occurring outside of the United States. In 1912, 1913, and 1914, G. N. WALCOTT, while working for the Porto Rican government, collected a number of *Tiphia* cocoons from various parts of the United States. Most of the adults emerging from these cocoons were used in cage experiments but from a lot of material that was collected in the autumn of 1914, 79 per cent of the emerging adults were liberated in cane fields in Porto Rico. Since the liberation of these adults no specimens of any American species of *Tiphia* have been reported from the island of Porto Rico and it is surprising to find an American species in the Dominican Republic now.

CHAS. T. GREENE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Dr. HENRIK LUNDEGÅRDH, Director of the Ecological Station, at Torckov, Sweden, recently gave at the Department of Agriculture an illustrated account of investigations in plant ecology conducted on the island where his station is located.

A Bibliography of Bibliographies on Chemistry and Chemical Technology, 1900-1924, by CLARENCE J. WEST and D. D. BEROLFEIMER, is announced by the National Research Council, Washington, D. C., as their Bulletin No. 50 (308 p., \$2.50). This work is composed of the following sections. General Bibliographies, Abstract Journals and Year-Books, General Indexes of Serials, Bibliographies of Special Subjects, and Personal Bibliographies. As the title indicates, the work is a compilation of bibliographies published as separates, or at the end of books or magazine articles, or as footnotes to the same, on the numerous aspects of pure and applied chemistry. Each entry gives name of author or compiler, title, and place of publication and most of them state the number of references. An approximate analysis shows that there are about 2400 subject headings, 7500 author entries and a total of 10,000 individual bibliographies.

The seventh annual meeting of the American Geophysical Union and of its sections will be held April 29 and 30, 1926, in the Building of the National Academy of Sciences and the National Research Council at 21st and B Streets, Northwest, Washington, D. C., with the exception noted in the schedule. The schedule of meetings is as follows:

April 29—9:30 a.m. to 12:30 p.m., Section of Geodesy; 2:30 p.m. to 5:30 p.m., Sections of Volcanology and Oceanography; 8:00 p.m. to 11:00 p.m., Section of Terrestrial Magnetism and Electricity (in the assembly room of the Administration Building, Carnegie Institution of Washington, 16th and P Streets, Northwest).

April 30—9:30 a.m. to 12:30 p.m., Sections of Meteorology and Seismology; 2:30 p.m. to 5:30 p.m., general meeting of the Union.

The Petrologists' Club met at the home of H. G. FERGUSON on February 2. Program: B. S. BUTLER: *Some features of the tops of Keeweenawan lava flows*; N. L. BOWEN: *Crystalline compounds in the lime-soda silica system*; H. S. WASHINGTON: *Italite from the Alban Hills*.

The Pick and Hammer Club met at the Geological Survey on January 23, to hear reports on the geological papers presented at the Kansas City meeting of the American Association for the Advancement of Science, and the New Haven meeting of the Geological Society of America.

Dr. L. H. DEWEY, chief of the Office of Fiber Investigations, Bureau of Plant Industry, has gone to Porto Rico for two months of field work.

Dr. JANET PERKINS, an American botanist long resident in Berlin, author of numerous works in systematic botany, is visiting Washington. She is studying collections at the National Herbarium.

PETER KLAPHAAK, assistant pathologist in the Office of Sugar investigations, Bureau of Plant Industry, died December 14, 1925, of pneumonia. Mr. Klaphaak was born and educated in Holland, and did post-graduate work at the University of Michigan. He had been working on the mosaic disease of sugar cane in the Department of Agriculture for the last few years.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 16

MARCH 4, 1926

No. 5

TERRESTRIAL MAGNETISM.--*The magnetic and electric survey of the earth: Its physical and cosmical bearings and development.*¹
J. A. FLEMING, Department of Terrestrial Magnetism, Carnegie Institution of Washington.

The last presidential address² covered so thoroughly and admirably the progress during the past quarter-century of research respecting the earth's magnetic field that I fear the presentation of my subject-matter may impose some repetition upon you. My excuse, however, is that you have brought it upon yourselves since apparently the accepted rule is that presidential addresses should cover efforts or developments in the particular science in which the speaker is engaged and, therefore, presumably competent to speak.

In terrestrial magnetism and electricity, as in most physical sciences, coordinated data and experiment must pave the way for the development and test of theory. The problems presented are extremely complex and so interrelated with other physical, geophysical, and cosmical ones that they offer greatest resistance to attack; their solutions, therefore, call in marked and exceptional degree for cooperative endeavor of the highest and most unselfish caliber. Herein appears to lie the most promising hope of ultimate successful interpretation, in part or in whole, of the many fascinating complexities and variations shown by these fields of the earth and its atmosphere.

In the collection of data through the magnetic and electric survey of the earth attention must be given to the geographical and space distributions and the time variability characterizing the phenomena

¹ Address of retiring President of the Philosophical Society of Washington, January 9, 1926.

² D. L. HAZARD, *This JOURNAL* 15: 111-125, 1925.

concerned. The word "survey" is here used in a broad sense to include not only isolated land and sea observations to determine the geographic distribution and long-period variations but also continuous work at fixed observatories to follow the time variations and coordinated effort in the physical laboratory, in the astronomical and astrophysical observatory, and in the instrument shop.

The survey, so far as the earth's magnetic field is concerned, may be said to have had its inception in the work of Halley on the *Paramour Pink* during 1698 to 1701 "on an expedition to improve the longitude and variations of the compass" in the north and south Atlantic oceans under the auspices of the British Government. To its leader we owe the method of portraying by isomagnetic curves the distribution of the magnetic elements although he used it only for declination. At present the magnetic survey involves the measurement of the direction and intensity of the lines of magnetic force, that is, of the so-called magnetic elements on the earth's surface, namely, declination, inclination, and horizontal intensity. Defining the magnetic meridian at any place as the direction of the compass needle there, the declination is the angle between the magnetic meridian and the astronomic meridian, the inclination (or dip) is the angle which a magnetic needle mounted on a horizontal axis and swinging in the vertical plane containing the magnetic meridian makes with the horizontal plane, and the horizontal intensity is the horizontal component of the total intensity of the earth's field. Charts showing curves drawn through places of equal values of the magnetic elements are called isogonic, isoclinic, and isodynamic charts, respectively.

Our planet is not uniformly magnetized, and its magnetic poles are distant 1,200 miles and more from its geographic poles, with the north pole approximately in latitude 70° north and in longitude 96° west of Greenwich, and the south pole approximately in latitude 73° south and in longitude 156° east of Greenwich; the line joining these poles passes some 750 miles away from the center of the earth. In addition, there are many regions where local natural disturbances, for example, those caused by magnetic ore deposits, give rise to further irregularities in the earth's general field. Therefore, observations of the magnetic elements must be made at many places to delineate the field with reasonable correctness.

There are also progressive changes in the earth's magnetic elements, which vary from place to place and for the same place from time to time. Since no laws satisfactorily covering these phenomena have been found,

secular-variation observations, as they are called, must be made at widely scattered points and at frequent intervals of time so that the isomagnetic charts can be corrected for such progressive changes.

The complexity of the earth's magnetism is still further increased by other periodic and irregular changes. Thus there is a daily variation of each element, the range of which varies with time, geographic position, season, and sunspot frequency and other cosmical relations. There is also an annual inequality. Perhaps the most fascinating of the magnetic perturbations are those irregular ones known as magnetic storms. These are of various types. Some occur almost simultaneously over the whole globe, their intensity more frequently increasing as the station is nearer a magnetic pole. Others having more local characteristics occur, for example, on the daylight face of the earth. Types of disturbances are (1) those designated "pulsations" of a ripple-like or pulsatory character, (2) those called "sudden commencements" of sharp and sudden beginning without any marked preliminary indication in the record, and (3) others best defined by their designation as "bays" of less irregular character lasting about 30 minutes or less. Some have the feature of repetition at the same place and time of day over periods of three to five days and even more as though there were local clouds of ionized material rotating with the earth influenced by cosmic radiations on successive days until the clouds are dissipated; this type, when aurorae are visible as at high-latitude stations, exhibits parallel features of recurrence, a phenomenon beautifully shown in Mawson's recently published discussion¹ of the records of the aurora polaris made by the Australasian Antarctic Expedition. Magnetic storms are generally simultaneous with displays of polar lights, are related in some measure to the sun's condition increasing with increased solar activity, and are frequently accompanied by pronounced disturbances of the natural electric currents within the earth.

The data for the preparation of isomagnetic and isoelectric charts for a given epoch are obtained by observations at many "distribution" stations and by repeat determinations made from time to time at selected "secular-variation" stations. Those for the study and investigation of the short and complex periodic, progressive, and irregular inequalities of the earth's magnetism and electricity are obtained best from continuous observations extending over many years at fixed observatory stations. At present there are about 50 active magnetic observatories, of which less than 20 per cent carry on electric work.

¹ Scientific Reports, Ser. B., 2: Pt. 1, 1925.

Their geographic distribution is by no means ideal, fully 40 per cent being in Europe and only about 20 per cent in the southern hemisphere.

Natural electric currents or "earth-currents," originally noted by Barlow, circulate in the crust of the earth and are generally weak, but in times of disturbance may attain such strength as to interfere seriously with telegraphic transmission. These currents and the electric phenomenon of atmospheric electricity including polar lights may be grouped as the electric field of the earth and its atmosphere. The survey, so far as this field is concerned, may be said to have had its initiation with Franklin's classical kite experiments on the electrification of clouds and the nature of lightning and with the nearly contemporaneous work of Le Monnier which showed that even under cloud-free conditions the atmosphere is the seat of an appreciable electric field. The development of the study of the electric phenomena of the atmosphere advanced somewhat after the introduction of the quadrant electrometer by Kelvin and following the work of Exner. Greater study and development began after the introduction by J. J. Thomson of the ionic theory of the electrical conduction in gases, and under the enthusiastic leadership of Elster and Geitel the foundations were laid for present-day investigations of the electric field. These investigations have assumed, in the last decade, a greater importance because of their bearings on recent theories of electricity and because of their intimate association and correlations with the phenomena of the earth's magnetism with which strong parallelism as regards space and time distribution and variations is found. The range and perturbations of the electric diurnal-variations are very much greater than those for the magnetic elements and are much more dependent upon meteorological conditions, but on the other hand the change of absolute values with geographic position is not so great.

In general, the atmospheric-electric phenomena observed include potential gradient, conductivity, and ionization. On clear days the earth is negatively charged with respect to the air, and in the lower layers of the atmosphere the potential difference between the earth and a point in the atmosphere increases with its height above the earth. The change in potential per meter is defined as the potential gradient; under good meteorological conditions its average value determined at many stations on land and sea is of the order of 125 volts per meter at sea-level, that is to say, the potential of the air 1 meter above the ground is 125 volts higher than the potential of the ground. Fair-weather values of the negative and positive conductivities of the lower

atmosphere are of the order of 10^{-4} E.S.U., the positive conductivity being in general 10 to 20 per cent larger than the negative conductivity. Observations of ionic content indicate average values ranging from 500 to 1,000 ions of either sign per cubic centimeter, the number of positive ions being about 20 per cent greater, thus leaving a volume charge in the atmosphere amounting to several hundred free positive ions per cubic centimeter. Values of the air-earth current-density from simultaneous observations of potential gradient and conductivity are of the order of 10^{-4} E.S.U., the value being somewhat greater over land than over sea.

The contribution to the survey through continuous work at fixed observatories was initiated by Gauss in the establishment in 1832 of a magnetic observatory at Göttingen to measure variations of declination and horizontal intensity. Following this, with the assistance of Weber and Humboldt, Gauss aroused such interest that international cooperation for the extension of the survey to regions unexplored magnetically was effected soon after 1840 in the establishment of a number of observatories in widely separated parts of the world and in the development of satisfactory instruments for determining all three magnetic elements and their variations. The history of the development of observatory methods, instruments, and progress is of great interest but must be passed over to permit some account of the survey and of results obtained in the last two decades, of their physical and cosmical bearings, and of the future needs.

The contribution to the magnetic and electric survey to which I wish to refer more in detail is that⁴ in which I have had the privilege for the past 20 years to work with Bauer, Peters, Ault, Fisk, Mauchly, and others in the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and which has been an effective agency for coordination and cooperation. While a large share of the general survey has been taken by that Department, very notable contributions have been made by various countries either through repetition of former magnetic surveys or through new surveys. Our work has been confined mainly to the oceans and to those countries or regions where magnetic data were generally lacking. In some regions the magnetic surveys required were accomplished by cooperation with existing organizations or with interested individual investigators. Furthermore, particular effort has been made to use every opportu-

⁴ C. I. W. Year Books, 4-24: 1905-1925. C. I. W. Pub. No. 175, 1-5: 1912, 1915, 1917, 1921, 1926

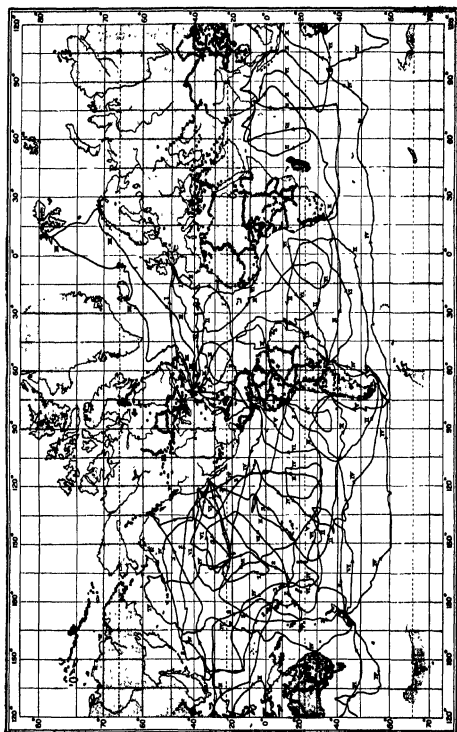


Fig. 1.—Magnetic Survey Work of the Carnegie Institution of Washington during 1906-1925. (Cruises of the *Gabiler* are indicated by Arabic numbers, those of the *Carnegie* by Roman numerals. Black dots show the land stations.)

ity to cooperate with expeditions¹ to the polar regions where data are very scarce. Such work was done on the Peary Arctic Expedition, the Australasian Antarctic Expedition under the leadership of Mawson, the *Maud* expeditions of Amundsen in the Arctic Sea during 1918 to 1921 and 1922 to 1925, and the Baffin Land and North Greenland expeditions under the command of MacMillan during 1921 to 1922 and 1923 to 1924.

To determine with requisite completeness the so-called Gaussian coefficients defining at any one epoch the earth's general magnetic field for investigating the theory and origin of the earth's magnetism, accurate values of the magnetic elements are needed at fundamental points which may be about 5° apart in latitude and longitude or about one station for each 100,000 square miles. On land, because of the frequent local and regional disturbances often caused by geological formations, the endeavor has been to attain distribution of primary stations on the average of one about every 5,000 square miles. For regions of local disturbance, observations are generally made at subordinate stations near the primary ones, but at sea, because of the usual absence of local disturbance, except in shallow waters or near land masses, stations may be much farther apart than on land. The land work (see Fig. 1) has been carried on, to greater or lesser extent according to circumstances, in every major political subdivision of Africa except British and Italian Somaliland; in every country in Asia excepting Afghanistan, the Himalayan States, and Chosen, but including every province of China except Tibet; in every state of Australia; in New Zealand; in 11 European countries; in every country of North America; in Greenland and Iceland and the ice of the Arctic Sea; in every country of South America; in the principal islands of the Atlantic and Indian oceans; and in 25 of the principal groups and isolated islands of the Pacific Ocean. During 1905 to 1925, inclusive, nearly 5,000 stations were established. In the last five years many of the stations have been reoccupied, so that at the present time from 60 to 70 per cent of the work done each year consists of such reoccupations which now number nearly 700 (see Fig. 2). Table 1 summarizes the land stations geographically, showing also the distribution of secular-variation primary stations.

Now that the greater part of the necessary distribution of magnetic stations has been realized, increasing attention is being given to obtain-

¹ C. I. W. Pub. No. 175, 1: 115-116, 1912. C. I. W. Pub. No. 175, 2: 127, 1915. *Terr. Mag.*, 27: 36-56, 1922. C. I. W. Year Book, 21: 278, 1922; 24: 188, 194, 1925. C. I. W. Pub. No. 175, 5: 191, 1926.

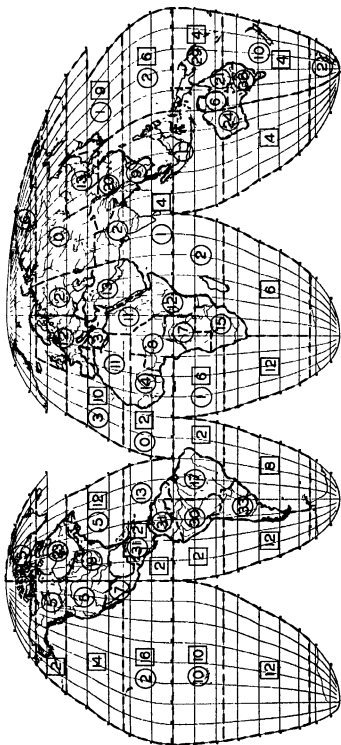


Fig. 2.—Regional Distribution of Magnetic Secular-Variation Data through December 31, 1925, obtained by the Carnegie Institution of Washington. (Numbers in circles apply for land work and in squares for sea work. Base-map is that of J. Paul Goode, copyright by the University of Chicago Press.)

ing secular-variation data. Particular attention has also been given the selection of primary secular-variation stations so that together with existing observatories they may form a net with approximately 500-mile intervals. Since 1922 the diurnal variations in the three magnetic elements on some one day for each have been determined at every reoccupation, using the combined C. I. W. magnetometer-

TABLE 1.—GEOGRAPHIC DISTRIBUTION OF MAGNETIC WORK ON LAND BY THE CARNEGIE INSTITUTION OF WASHINGTON DURING 1905-1925

GEOGRAPHICAL DIVISIONS	STATION OCCUPATIONS			REPEAT LOCALITIES
	Primary	Auxiliary	Secondary	
Africa.....	1053	56	13	88
Asia.....	755	63	39	64
Australasia ...	612	57	78	96
Europe... ..	94	31	0	14
North America	586	122	31	77
South America .. .	815	111	31	111
Islands:				
Atlantic ..	154	115	47	30
Indian .. .	94	16	9	4
Pacific .. .	188	48	25	44
Mediterranean....	8	0	0	3
Antarctic .. .	25	1	5	2
Arctic Sea	26	67	212	1
Totals.	4410	687	499	534

inductor. These data will be used in the determination of correction-factors to reduce to mean of day with the aid of data at observatories more or less distant from the field stations. Such a net-system of stations has been planned for Mexico, Central America, and South America, and observations have been made accordingly. Similar nets have been begun in Australia and Africa and at scattered points elsewhere. The results so far amply justify the plan, though there is room for improvement which ultimately must come with the development of instruments better adapted to this particular form of land work. The need is to secure secular-variation data at intervals of five years and even at shorter intervals in those regions where the changes are unusually rapid. To insure continuance of a series it is planned to observe always at one or two stations comparatively close to the primary secular-variation stations, thereby making it possible to transfer the series in case the station originally selected becomes unsuited.

The ocean work^a of the Department was initiated in 1905. The early work in the Pacific Ocean during 1905 to 1908 was carried out on the chartered brigantine *Galilee*. In 1909 a specially designed non-magnetic vessel, the *Carnegie*, was built, and all our work at sea since that time has been done with this vessel excepting a special expedition into Hudson Bay in 1919 on a chartered schooner. The summary of ocean magnetic work of the *Galilee* and the *Carnegie* during 1905 to 1921 as given in Table 2 (see also Fig. 1) shows the total number of

TABLE 2—SUMMARY OF MAGNETIC WORK AT SEA BY THE GALILEE AND THE CARNEGIE DURING EIGHT CRUISES IN 1905-1921

OCEAN AND APPROXIMATE SPACES OF OBSERVATION	NUMBER OF NAUTICAL MILES	NUMBER OF OBSERVED VALUES		CRUISE INTER- VALS USED FOR ANNUAL CHANGE DATA	SQUARE STATUTE MILES PER STATION	
		Declina- tion	Inclina- tion and horizontal intensity		Declina- tion	Inclina- tion and horizontal intensity
Pacific. 1905-08, 1912, 1915-16, 1921	181,423	1,800	1,183	47	35,600	53,700
Atlantic. North, 1909-10, 1913- 14, 1919, South, 1910-13, 1920	92,053	1,039	682	27	30,300	46,800
Indian. 1911, 1920 . . .	43,060	477	282	7	59,100	99,800
Total	316,536	3,316	2,147	81	37,300	57,800

observed values of declination to be over 3,300, and of inclination and horizontal intensity to be over 2,100, the stations being distributed in the Pacific, Atlantic, and Indian oceans in the proportion of about 4, 2, and 1, respectively. The average time-intervals and the average distances apart for stations for the *Galilee* work have been decreased by about 40 per cent in the *Carnegie* work because of the increased efficiency resulting from the fact that the *Carnegie* was built for the work and because of the steady improvement in the instrumental appliances and observational methods. While the oceans have now been quite thoroughly traversed between parallels 60° north and 60° south, there still remain areas of 500,000 square miles or more in extent, especially in the Pacific Ocean, within which no magnetic observations have been made. However, the area in general for each declination station is less than half the theoretical requirement of 100,000 square miles, and for an inclination and intensity station about three-fifths of the theoretical requirement. Thus it may be said that there are

^a C. I. W. Year Book, 4: 264-274, 1905. C. I. W. Pub. No. 175, 3, 5: 1917, 1926.

available accurate ocean magnetic data at points distributed about 3° in latitude and 3° in longitude or, on the average, about 200 miles apart.

The results of the ocean work have been incorporated in the isomagnetic charts of the leading hydrographic offices, and chart-errors, which reached an appreciable magnitude in 1905, are now within limits sufficient for all economic purposes and to a large degree for general magnetic investigations. Such as do exist may usually be attributed to imperfect knowledge of the secular changes which are more complicated even over the deep sea than was supposed to be the case.

TABLE 3.—ATMOSPHERIC-ELECTRIC STATIONS AT SEA AND DIURNAL-VARIATION SERIES DURING CRUISES OF THE *CARNEGIE*, 1915-1921, FOR ONE OR MORE ELEMENTS AND SERIES OF FOUR HOURS OR MORE

CRUISE	OCEAN							
	Atlantic		Pacific		Indian		Southern	
	Number of stations	Number of D V series	Number of stations	Number of D V series	Number of stations	Number of D V series	Number of stations	Number of D V series
IV	22	1	293	27			76	14
V	38	2	66	7				
VI	164	8	178	27	118	10		
Totals.	224	11	537	61	118	10	76	14

Total for all oceans 1915-1921 stations, 955, diurnal-variation series, 96

During the earlier work of the *Carnegie* atmospheric-electric observations were made at sea primarily to develop methods and appliances for the determination of electric distribution. Much of this preliminary work gave relative values only, but as the result of this work and of experimental work in the laboratory it was possible, beginning in March 1915 with the fourth cruise of the vessel, to make systematic absolute determinations of the atmospheric-electric elements at sea.

The atmospheric-electric results⁷ at sea from 1915 to 1921 include potential gradient (see Fig. 3), negative and positive ionic content, conductivity, and ionic mobility, penetrating radiation, radioactive content, together with accompanying detailed meteorological data. They are summarized in Table 3 for 955 stations in all oceans at which one or more elements were observed and for 96 series for diurnal-

⁷ C. I. W. Pub. No. 175, 3: 361-422, 1917; 5: 385-424, 1926.

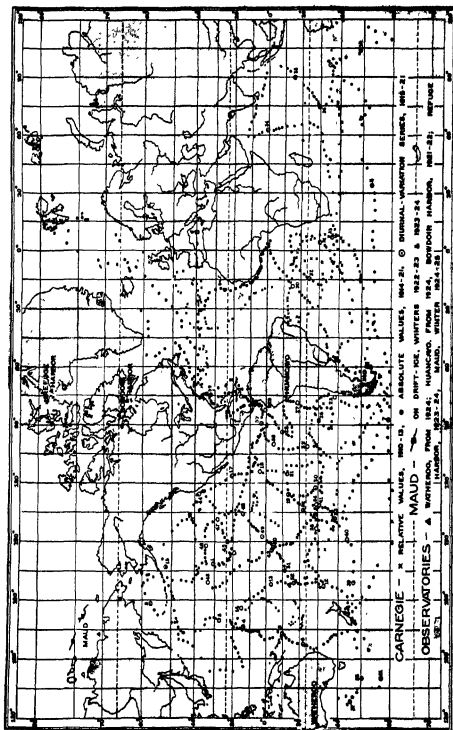


Fig. 1.—Electric Survey Work of the Carnegie Institution of Washington during 1910-1926. (Distribution of atmospheric potential gradient stations of the Carnegie, of the *Maud*, and at observations.)

variation of one or more elements including four hours or more of observation.

The question of standards to coordinate the work by various organizations the world over and in the development and design of instrumental appliances, especially for the high order of precision attained in the magnetic observations, has been important. There being no agreement among nations as to international magnetic standards, it was necessary that the Department of Terrestrial Magnetism adopt standards in 1905 at the very beginning of its work.⁸ Control of the instrumental constants has been carefully maintained, and the precision of the provisionally adopted standards to the order of 0.2 in declination and inclination and of one five-thousandth part in horizontal intensity has been confirmed by frequent and detailed intercomparisons (1) with field and observatory instruments of various types at the Standardizing Magnetic Observatory in Washington, (2) at over 80 per cent of the active magnetic observatories of the world repeated at intervals of from three to five years at the leading observatories, and (3) with absolute electric instruments especially designed for the determination of the magnetic intensity and inclination. The standard in horizontal intensity is justified within the limit of reasonable precision by the results, direct and indirect, of comparisons with electromagnetic instruments summarized in Table 4. Of this type of instrument three have been designed and constructed within recent years,⁹ namely, the Barnett sine-galvanometer of the Carnegie Institution of Washington, the Schuster-Smith magnetometer of the National Physical Laboratory at Teddington, and the Watanabe electric magnetometer of the Japanese Central Bureau of Weights and Measures; the constants for all three instruments are based on absolute electrical units.

These investigations of magnetic standards have stimulated great interest and have been supported by most generous cooperation in time and laborious observation by practically every organization engaged in the world survey. The importance of the subject has been recognized in recent resolutions¹⁰ and recommendations on governmental and international control of standards by such bodies as the International Geodetic and Geophysical Union in 1924 at Madrid and

⁸ C. I. W. Pub. No. 175, 2: 211-278, 1915, 4: 395-475, 1921.

⁹ C. I. W. Pub. No. 175, 4: 273-294, 1921. Proc. Phys. Soc., 26: 279-291, 1914. Proc. Phys.-Math. Soc. Japan, Ser. 3, 2: 210-223, 1920.

¹⁰ Trans. Sec. Terr. Mag. Elect., Madrid, 1924. K. Ned. Met. Inst., No. 112, 1924.

the International Meteorological Conference of Directors and the International Meteorological Committee in 1923 at Utrecht.

TABLE 4—SUMMARY OF RESULTS OF HORIZONTAL-INTENSITY COMPARISONS BETWEEN PROVISIONAL INTERNATIONAL MAGNETIC STANDARD OF CARNEGIE INSTITUTION OF WASHINGTON AND ELECTRIC MAGNETOMETERS, AUGUST, 1922, TO MARCH, 1923*

STANDARD OR INSTRUMENT		HORIZONTAL-INTENSITY CORRECTION, $\frac{\Delta H}{H}$, OR			
Description	Designation	IMS	SG	SS	W
Provisional International Magnetic Standard of Carnegie Institution of Washington†	IMS		+0 00007	+0 00015‡	+0.00031
Sine galvanometer No. 1 of Carnegie Institution of Washington . .	SG	-0 00007		+0 00008‡	+0.00024
Schuster-Smith magnetometer of National Physical Laboratory..	SS	-0 00015‡	-0 00008‡		+0.00016
Watanabe electric magnetometer No. 1	W	-0 00031	-0 00024	-0 00016‡	

* The table is to be read thus, for example first row: $SG - IMS = +0.00007H$; $SS - IMS = +0.00015H$; $W - IMS = +0.00031H$. The results are based for the three electric instruments on absolute units.

† This provisional standard was adopted in 1914 (see *Res. Dep. Terr. Mag.*, Vol. II, 1915, pp 270-279).

‡ This value is subject to correction for any station-difference which may be found between the two observing piers used at Teddington, England, for the comparisons in September 1922.

Continued extensive field use of the C. I. W. magnetometer-inductor¹¹ for the determination of declination and horizontal intensity by magnetic methods and of the inclination by the inductor method shows this type of instrument to be very satisfactory even under most severe conditions. The time required for complete determinations of the three magnetic elements using the magnetometer-inductor is greater than would be required by an instrument based entirely on electro-magnetic methods, but the difficulties of maintaining electric batteries and appurtenances on long journeys under severe and variable field conditions would offset any gain by such an instrument since the actual time required for magnetic observations is but a small part of that required for all the work at a field station. In view, however, of the desirability of portable designs of electromagnetic instruments for observatory and special field use, for example, diurnal-variation work at land stations and on board ship at sea, an electric magnetometer and

¹¹ *Terr. Mag.*, 18: 105-110, 1923.

variometers with rotating coils are being designed for the observation of declination and, by suitably mounting the coil on a horizontal axle permitting orientation of its rotation axis at any angle, of the intensity-components, and inclination.

The Carnegie Institution of Washington following its policy, not to duplicate the work of other organizations but to obtain data where most needed for world-wide considerations and development, has in operation two magnetic and electric observatories in the southern hemisphere, where the distribution of existing observatories is most inadequate. One at an elevation of about 800 feet, is near Watheroo, Western Australia, about 125 miles north of Perth, and the second at an elevation of 11,000 feet above sea-level, is near Huancayo, Peru, practically on the magnetic equator and some 120 miles east of Lima. Both these observatories maintain the full program of observational and investigational work in terrestrial magnetism, atmospheric electricity, and earth-currents. The Institution is cooperating also with the New Zealand Government in the maintenance of the atmospheric-electric program at the Apia Observatory which, because of its location in the midst of the Pacific, is a unit of large importance in the magnetic and electric survey. The great altitude above sea-level of the station at Huancayo and its location, practically on the magnetic equator, with the possibility of auxiliary stations within 100 miles at differences of elevation of as much as two miles, affords unique opportunity at least for initial work in the study of altitude effects on the magnetic and electric fields. Time at all three observatories is determined by means of radio signals, thus insuring the accurate time control necessary to the study of the propagation of magnetic disturbances.

Now that the distribution stage of the general magnetic and electric survey of the earth is practically completed, we must look forward to the future needs of this survey, for as Humboldt says, "the interpretation of an undertaking of such cosmical importance depends on its long continued repetition." But first it is necessary to consider in how far we must call further upon cooperation from the physical laboratory, the astrophysical observatory, and related geophysical observations for help in interpreting the results and discussions so far made, for quoting Burgess¹² in his presidential address to this Society, "A scientific man would hardly be so rash as to pose as a prophet, yet he may, nevertheless, try to assemble and pass in review some of

¹² This JOURNAL 9: 57, 1910.

the tendencies of the time; and it is only by an intelligent examination of the underlying changes which are being produced in science and in its relation to society that he is enabled to see his way ahead a little more clearly into the mist of the future; and he may thereby be enabled, at least in some small degree, to chart his course and take advantage of the various currents that have been set in motion."

Among some results thus far obtained as a result of the magnetic and electric survey may be mentioned the following: The analysis¹³ of the earth's magnetic field for the epoch 1922 for the first time based upon thoroughly homogeneous data between the parallels of 60° north and south as discussed by Bauer and his co-workers, which shows that about 95 per cent of the earth's magnetic field is to be ascribed to internal magnetic and electric systems, about 3 per cent to external systems or systems in the atmosphere and the remainder, about 3 per cent, to a magnetic system the evoking agencies of which, for example, vertical electric currents, may pass from the atmosphere into the earth and out again. Although the last two systems contribute only about 6 per cent to the magnetic field as observed on the earth's surface, their further study may be of first importance in revealing entirely new facts in the investigation of the origin of the earth's electric field. This discussion also shows that the secular variation results from changes in both direction and intensity of magnetization with the lapse of time. The intensity apparently has steadily decreased during the past 80 years at an average annual rate of one fifteen-hundredth part, and its average value for corresponding parallels north and south is generally larger for land-predominating than for ocean-predominating parallels. There are, however, larger secular changes in the southern or ocean-predominating than in the northern or land-predominating hemisphere. The internal uniform magnetic field of the earth as deduced from this work for 1922 is 8×10^{23} c.g.s., the relation of its components parallel and perpendicular to the earth's axis of rotation being about as five to one.

Secular-variation studies over the sea¹⁴ by Ault and Peters and over land by Fisk,¹⁵ especially those for Latin America and adjacent waters including all of South and Central America and the Atlantic and Pacific oceans adjoining, show results singularly like long-period types [of pulsation about primary and secondary foci, and perhaps not unre-

¹³ Terr. Mag., 18: 1-28, 1923.

¹⁴ C. I. W. Pub. No 175, 5: 185-191, 1926; 3: 430-435, 1917.

¹⁵ Terr. Mag., 29: 139-148, 1924.

lated to those amplitude pulses of regular diurnal inequality, which vary accordingly as the disturbance waxes and wanes, so strikingly brought out by Chree's discussion¹⁶ of magnetic phenomena in the region of the south magnetic pole. The accumulated data of the ocean survey emphasize the disadvantage of attempting to control normal secular-variation by observations at isolated island stations, most of which are notoriously centers of local magnetic disturbance; thus far, intensive work by the Department on relations of secular and diurnal variations in such locally disturbed regions has been confined to that of Fisk in the Bermudas. Ault finds, from his discussion of ocean results, regions of apparent anomaly at sea which suggest the need of sounding to determine topography and effect of sea bottom since places have been noted where residuals are persistently of the same sign over limited areas.

The discussions and analyses by Bauer, Mauchly, and their colleagues of the extensive atmospheric-electric observations at sea since 1915 have yielded results and conclusions also of fundamental importance.¹⁷ Thus Mauchly finds the chief component of the diurnal variation of the potential gradient over the oceans is a "wave" of 24-hour period occurring simultaneously in the same phase in all localities and from consideration of land series a strong probability is established that, in general, this 24-hour wave progresses also approximately according to universal time over the entire land surface of the earth. The greatest value of the gradient occurs at an average during the year of between 17^h and 19^h Greenwich mean time, which is approximately the time when the Sun is in the meridian of the north magnetic pole of the earth, a fact indicating possibly a close relationship between the magnetic and electric fields; thus far, the character of this relationship is unexplained. In cooperative work of the Department with the Arctic-Drift Expedition of Amundsen, beautiful confirmation of this fundamental deduction has resulted from series of observations during the three winters of 1922 to 1925 through the work of Sverdrup.¹⁸ These observations were obtained during the first two winters in the drifting ice observatory off the north coast of Siberia and during the last winter at a temporary land station near Bear Island. The data obtained for density of air-earth current from simultaneous potential-gradient and conductivity results at sea show also that atmospheric-electric

¹⁶ London, Proc. R. Soc., A, 104: 165-191, 1923.

¹⁷ C. I. W. Pub. No 175, 3: 361-422, 1917; 5: 385-424, 1926.

¹⁸ MS. Scientific work of the *Maud* Expedition, 1922-1925.

phenomena can not be wholly interpreted on the basis of local conditions, however characteristic such features may be

Not only in this but also in the evidence of solar-activity correlations is the value of a moving observatory such as the *Carnegie* clearly shown. The studies¹⁹ by Bauer of sunspot and annual variations of atmospheric electricity and by Mauchly in atmospheric electricity, both as based on the observations during 1915 to 1921 aboard the vessel, show beautifully the close parallelism during this period of observation in all oceans between waxing and waning in sunspot activity and atmospheric potential-gradient—a parallelism whose confirmation indeed is as evident from the sea observations as it is from observations made at fixed land observatories during the same period. The general conclusion from the investigations of Bauer, Peters, Duvall, and Ennis based on land and ocean results indicates that during the cycle 1913 to 1922 the atmospheric potential-gradient increased with increasing sunspottedness by at least 20 per cent of its mean value for the cycle between the years of minimum and maximum sunspottedness. This also applies with regard to measures of diurnal variation and of annual variation of the potential gradient. The evidence, ever growing with the accumulation of observational data, that the annual variation progresses according to the time of year rather than according to local seasons, is significant from the viewpoint of solar relationship, also the maxima of activity occur near the equinoctial months March and September and the minima of activity near the solstitial months June and December, corresponding as well to the fluctuations in the activity of earth-currents and in the frequency of the northern lights.

From the great number and distribution at sea of the atmospheric-electric data secured (as shown in Fig 3) it is now possible to prepare, tentatively, the first isoelectric chart of the oceans which shows the potential gradient varying with latitude. The regular increase from the equator to 60° north and to 60° south again suggests world-wide predominance of the chief features of this element.

A most promising method of examining the apparent interrelations of the earth's magnetic activity represented by the magnetic storms and the solar activity represented by sunspot data extending now more than a century back, is by investigating abruptly beginning magnetic storms or "sudden commencements." Recent studies by Bauer and Peters²⁰ of data for the high sunspot period 1906 to 1909 and for the

¹⁹ C I W Pub No 175, 5 359-384 and 385-424 1928

²⁰ Terr Mag, 30 45-68, 1925

low sunspot period 1922 to 1925 indicate possibly an origin in low magnetic latitudes and progression to the magnetic poles with an average speed around the earth such that the uninterrupted progression of an average disturbance of this type from the magnetic equator to the pole might take about 1.8 minutes. Here we see, as in other problems of cause and effect, the necessity of the greatest precision and accuracy not only in record but in thorough analysis and discussion of the magnitude of errors of the record and particularly of the time element. These studies also show the necessity of establishing a greater number of recording stations in regions where limiting conditions of the phenomena prevail, namely, the Arctic and Antarctic—a desideratum recognized by resolutions of the International Geodetic and Geophysical Union at Madrid in October 1924. Observational data regarding such propagation have been previously discussed²¹ by Bauer, Faris, Chree, Chapman, Angenheister, and Rodés, with various conclusions. We must improve the control of time as recorded on the photographic records to insure accurate timing of given features to within one-fourth minute at least and to determine in how far the feature of a sudden commencement may be identical or vary with geographic distribution. This research shows need of a more accurate and reliable method for recording vertical intensity than the present type of variometer.

Briefly, some of the future needs and lines of development for the magnetic and electric survey, therefore, include (1) continued accumulation of data on land and sea, less intensive than heretofore as regards distribution stations but more so as regards observatories, and (2) concurrent theoretical discussions, experiments, and investigations in the physical laboratory and in the astronomical observatory.

While the first general ocean survey covering so large a part of the earth's surface is largely accomplished, there is still great need for additional data for the determination and investigation of marine earth-currents, for the important question of magnetic secular-variation or progressive changes and their accelerations over ocean areas, and for the examination of regions of local magnetic disturbance. There is also great need for more data for the study of the diurnal and other variations and the distribution of the electric elements and their magnetic interrelations for which sea conditions are superior to

²¹ *Terr. Mag.*, 15: 9-30, 93-105, 1910. Göttingen, *Nachr. Ges. Wiss., Math.-Phys. Kl.*, 1913. London, *Proc. Phys. Soc.*, 27: 134-153, 1914, 30: 205-214, 1918. *Terr. Mag.*, 27: 162-166, 1922; 30: 45-68, 1925.

those on land, where topography, culture, and variable meteorological elements mask the true characteristics of the phenomena. Instrumental improvements based on electromagnetic principles should include the actual continuous or semi-continuous recording by photography of the magnetic and electric fields at sea.

The practical impossibility of realizing a network of continuous recording observatories so close together as to permit direct interpolation to correct survey data for diurnal variation makes some provision necessary for deriving diurnal variations for each of the elements at selected field stations. Comparisons of such data with records obtained simultaneously at the nearest observatory must increase our limited knowledge of the way in which the range, time of extremes, and other characteristics of the diurnal variations change from place to place and in the two hemispheres. The recent extraordinary developments in the evolution of physical science demand increased accuracy and constant functioning of observatory recording instruments. While the present declination and horizontal-intensity variometers are of high precision, the vertical-intensity variometer is not entirely satisfactory, because certain mechanical difficulties inherent in suitably supporting the moving magnetic element cause frequent discontinuities of base-line and of scale-value. An important instrumental need, therefore, is the design and construction of variation instruments on electrical principles, for example, by means of rotating coils oriented appropriately for the study of the various intensity components with recording galvanometers of sensitivity suited to various problems being studied.

Upper-air observations of the magnetic and electric elements and similar observations below the surface of the land and sea are needed because magnetic and electric activity, diurnal ranges, and other periodic and irregular variations may undergo considerable modification with changes in altitude, as is already indicated by the few data gathered in upper-air electric work. Such development calls for careful study of methods and the design of instruments most suitable for accurate determinations of changes above the surface of the earth in unmanned carriers or below the sea in bells.

The magnitude of the work of observation, control, and reduction of magnetic and electric data from continuous records at observatories is appallingly great, and most urgent needs include development of simplified methods for such reductions and for publication. There also is need of better theoretical foundations for really representative

but simple scales to characterize magnetic and electric activities upon which to build relations with physical and cosmical phenomena. To make possible the complete mathematical analyses of the magnetic and electric fields, it is very desirable that additional observatories be established and distribution stations be occupied in regions where auroral displays are frequent and where limiting conditions of the other phenomena prevail. In the regions above latitude 60° north and 50° south, that is, over 18 per cent of the earth's surface, there are very few data. Therefore, every advantage must be taken of every opportunity to cooperate with, and to encourage such work by, polar expeditions.

The world-wide increasing interest in the magnetic and electric survey has been such within the past few years that many countries heretofore inactive in such work have taken it up intensively both at field stations and at observatories. Through the rapid development and design of special instruments and standardized equipment, it is now possible to obtain physical coordination of new work being undertaken. Cooperative efforts with physical laboratories and astronomical observatories are evolving and offer much promise. Thus a research between the Geophysical Laboratory and the Department of Terrestrial Magnetism on the effect of pressure on the critical temperature of magnetization for pure metals and natural ores is in progress, and may yield results not only applicable in the investigation of the contribution of magnetized materials in the earth's crust to the permanent magnetic field but also to physics, to geology, and to applied geology in the detection of ore deposits. Cooperative work²² has recently been carried on by the Department with the Bureau of Standards, the Naval Research Laboratory, and various other organizations interested in questions concerned with upper-air conductivity particularly with the supposed Kennelly-Heaviside layer. Breit and Tuve, through theoretical and experimental attack evolved from an idea originally suggested by Swann, have recently shown the existence of such a layer at a height averaging about 150 kilometers above the earth's surface. Such a layer affords a possible explanation of some variations in the earth's magnetic field according to which the motions of the layer induce electric currents which in turn may produce some of the variable part of the earth's magnetism, an idea advanced by Stewart, further developed by Schuster, and quantitatively considered by Chapman; the motion of the layer as a whole may affect the electrical con-

²² C. I. W. Year Book, 24: 1925.

dition of the lower atmosphere and produce changes in the observed atmospheric potential-gradient. Here again we have the possibility of an intimate relation in that the ionized gases of such a layer may consist largely of helium, and its further study may lead to better understanding of northern lights following the recent laboratory experiments²² of Vegard at Leyden and of McLennan and Shrum at Toronto.

Another development of the survey calling for experimental work in the laboratory is a proposed study of earth-currents at sea suggested by Mauchly and Gish. The extent and homogeneity of the oceans of our globe, as compared with land areas, are such that the ocean area must be given, as we have seen from the magnetic and atmospheric-electric results at sea, a large measure of consideration in the collection of any geophysical data that assume an approach to completeness. The homogeneity acts in a number of ways to make the sea especially favorable for the observations of earth-currents as compared with any of the available solid portion of the earth's crust.

The "penetrating radiation" or high frequency rays of cosmic origin, recently reported upon by Millikan²⁴ and also earlier investigated by Kohlhorster²⁵ and others, must have some bearing particularly on the electric field of the earth. These results stimulate further experimental investigation in the laboratory to give more definite information about the properties of penetrating radiation and its possible relation to the maintenance of the earth's charge; for example, investigations on the nature of the scattering of hard gamma-rays from various materials.

As regards the relations between atmospheric electricity and radio phenomena, Dellinger²⁶ has summarized specific interrelations to include (1) lightning and thunder-clouds and atmospheric disturbances, (2) variations of atmospheric potential-gradient and conductivity and similar variations of atmospheric disturbances in field intensities, and (3) earth's magnetic field and upper-air conductivity and differing radio-wave propagation at various frequencies.

Among the problems of the electric field demanding further consideration, as stated in the 1924 report²⁷ of the committee on observational

²² Comm. Phys. Lab. Univ. Leyden No. 175, 1925. London, Proc. R. Soc., A, 106: 501-512, 1925.

²³ Science, 62: 445-448, 1925. Nature, 116: 823-825, 1925.

²⁴ Die durchdringende Strahlung in der Atmosphäre, Hamburg, 1924.

²⁵ Bull. Nation. Res. Council, No. 53: 61-62, 1925.

²⁷ Trans. Soc. Terr. Mag. Elect., Madrid, 1924.

work in atmospheric electricity of the International Geodetic and Geophysical Union, are: (1) Character of the annual variation of potential gradient over the southern hemisphere as to whether as a whole its maximum is in the summer or in the winter and further observations confirming the universal-time function of the daily variation of potential gradient, a matter of fundamental importance, both calling for more measurements especially at sea; (2) more measurements for determining air-earth currents, if possible, by direct measurement of the electricity passing from a portion of the earth's surface into the atmosphere during the whole year taking into account current due to precipitation, these to be made at a number of widely-distributed stations, thus affording some means of determining the total loss of electricity from the earth's surface; and (3) additional measurements on the conductivity of the air and its variations and their changes with geographic position. Other problems which lend themselves better to investigation at individual stations involve the part played by different factors in ionizing the air, the electricity of thunder-storms and the distribution of electrical factors in the upper air. The development of instruments for air-earth currents and conductivity is still in the experimental stage.

The importance of cooperative work in the study of interrelation of solar activity and the magnetic and electric activities of the earth has been emphasized further by consideration of international bodies including the International Geodetic and Geophysical Union²² in 1924 and the International Research Council for the study of solar and terrestrial relationships in July 1925,²³ the latter calling particular attention to the necessity of organizing a service for the supply of information to solar observatories as to magnetic storms, prospective or in progress.

A possible extension of the survey is indicated in Chevallier's recent and interesting paper²⁴ discussing the direction of magnetization of various lava flows at Mount Etna. Following lines indicated by Folgheraiter, Brunhes, and others in studies of the magnetism of rocks and lavas and with a knowledge of the dates of eruption he has deduced declination secular-variation curves. Perhaps by the cautious use of such methods we may delve into the history of the earth's magnetism before the period of observation and even perhaps in geologic ages.

In a summary of some of the interrelations of the magnetic and elec-

²² Trans. Internat. Astron. Union, 2: 186-188, 1925.

²³ Ann. Phys., Paris, 4: 5-162, 1925.

tric survey with other branches of physical, geophysical, and cosmical work we may include: In oceanography and navigation—the study of local magnetic disturbances along coast lines, on islands and at sea as related to depths, bottom formations and earth-currents; in geology, geodesy and seismology—relations to magnetic and electric susceptibilities and character of materials in the crust of the earth, to gravity anomalies and to isostasy; in engineering and physics—relations to radio and telegraphic transmission, applications of magnetic and electric methods to mineral surveys and determinations, fundamental problems of magnetism, electricity and radiation; in meteorology and astronomy—relations to meteorological conditions including upper-air conditions, dust content and absorption and scattering of sun's radiation, to solar activity especially for measures other than visual, to penetrating radiation, to planetary motions, and to magnetic and electric conditions of heavenly bodies. All of these demand continued and incessant prosecution of the survey by observations at temporary stations and at fixed and floating observatories on the surface of the earth, in the upper regions of the atmosphere and in ocean depths, and in the physical laboratory and the astronomical observatory if we are to make nearer approach to the elucidation of the phenomena concerned. The continued cooperative efforts of international and national bodies and organizations and of physicists, geophysicists, astronomers, and astrophysicists must be looked forward to and counted upon in an ever-increasing degree in the future development and interpretation of the magnetic and electric survey of the earth.

PALEONTOLOGY.—*New Eocene mollusks from Jackson, Miss.*¹
WYTHE COOKE, U. S. Geological Survey.

For many years the writer has been accumulating data for a monographic account of the stratigraphy and paleontology of the formations of Jackson age in the United States, and from time to time he has published short papers dealing with the stratigraphy or correlation of some of those deposits.² As the completion of this report has been unavoidably delayed, it seems advisable to publish now some of the new species which were to have been described in it.

¹ Published by permission of the Director of the U. S. Geological Survey.

² The age of the Ocala limestone: U. S. Geol. Survey Prof. Paper 95: 107-117. 1915.

The stratigraphic position and faunal associates of the orbitoid foraminifera of the genus *Orthophragmina* from Georgia and Florida: U. S. Geol. Survey Prof. Paper 108: 109-113. 1917.

All of the shells figured in this paper are in the U. S. National Museum. They were collected by Dr. T. Wayland Vaughan and the writer from the Jackson formation (upper Eocene) at the stations listed below. With the single exception of *Turritella rivurbana*, which came from the Yazoo clay member on Town Creek, all are from the Moodys marl, which forms the basal member of the Jackson formation and underlies the Yazoo clay. The illustrations are from photographs made in the laboratory of the U. S. Geological Survey by Mr. W. O. Hazard and retouched by Miss Frances Wieser.

Station 4250. Moodys Branch, Jackson, Miss.: from the first bluff below the first bridge east of the Institution for the Blind. T. W. Vaughan, 1900.

Station 6458. Moodys Branch, Jackson, Miss.; S. W. $\frac{1}{4}$ sec. 35, T. 6 N., R. 1 E. Wythe Cooke 1912.

Station 6466. Town Creek, Jackson, Miss.; 200 yards south of the intersection of Rankin and South State Streets. Wythe Cooke, 1912.

Terebra jacksonensis Cooke, n. sp. Fig. 1

Shell slender, apical angle about 20° , suture distinct; nucleus containing 3 or 4 smooth, polished, convex whorls, postnuclear whorls $9\frac{1}{2}$ in type, ornamented by even, rounded, slightly sinuous axial ribs which are cut by an impressed spiral line one-third the width of the whorl in front of the suture and which become obsolete at the anterior end of the body whorl. Rounded fasciole bordered posteriorly by a strong cord which terminates abruptly at the inner lip. Altitude $13\frac{1}{2}$ mm.; lat. of body whorl $3\frac{1}{2}$ mm.

Station 4250, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,937.

This species, which is very abundant in the Moodys marl member at Jackson, somewhat resembles de Gregorio's figure of *T. andrega*, which has a deeper spiral furrow on the whorls.

Drillia dorseyi Cooke, n. sp. Fig. 2

Shell small, robust, apical angle 35° to 40° ; nucleus blunt, polished, containing about $3\frac{1}{2}$ convex whorls, about $\frac{7}{8}$ mm. long. Postnuclear whorls $4\frac{1}{2}$ in type, about $2\frac{1}{2}$ times as wide as long; polished, smooth or very faintly threaded back of the suture but distinctly threaded on the anterior half of the body whorl; decorated with 11 or 12 rounded, axial ribs on each whorl.

Deposits of Claiborne and Jackson age in Georgia (jointly with H. K. Shearer): U. S. Geol. Survey Prof. Paper 120: 41-81. 1918.

Correlation of the deposits of Jackson and Vicksburg ages in Mississippi and Alabama. This JOURNAL 8: 186-198. 1918.

Correlation of the Eocene formations in Mississippi and Alabama: U. S. Geol. Survey Prof. Paper 140: 133-136. 1925.

The Cenozoic formations [of Alabama]: Alabama Geol. Survey, Geology of Alabama (in press).

Suture distinct, somewhat flexuous. Canal straight; aperture about two-thirds as long as the body whorl. Outer lip broken. Alt. $5\frac{1}{2}$ mm.; lat. 2 mm.

Station 4250, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,938.

Drillia dorseyi is smaller, less slender, and has a somewhat shorter nucleus than *D. tantula* (Conrad) from the Byram marl at Vicksburg. A somewhat larger shell of 5 whorls, measuring $6\frac{1}{2}$ mm. in altitude and $2\frac{1}{2}$ mm. in latitude, has only 7 ribs on each whorl. It may be a distinct variety.

***Pleurotoma julia* Cooke, n. sp. Fig. 3**

Shell small, fusiform; apical angle about 30° . Nucleus large, smooth, tip broken, $2\frac{1}{2}$ whorls remaining. Postnuclear whorls $4\frac{1}{2}$ in type, shouldered cancellated; entire whorl covered by regularly spaced and nearly equal spiral threads, 7 threads on the third whorl; many low, rounded, protractive ribs becoming obsolete on the body whorl. Canal straight; aperture wide, three-sevenths as long as the shell; columella smooth; outer lip thin, smooth within. Sinus adjacent to the suture, shallow. Altitude 7 mm.; latitude $2\frac{1}{2}$ mm.

Station 4250, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,939.

This pretty little species, of which only one specimen is in the National Museum collection, is given the obsolete name "*Pleurotoma*" because of the chaotic condition of the nomenclature of the Turritidae.

***Cancellaria jacksonica* Cooke, n. sp. Fig. 4**

Shell large, stout, falsely umbilicated, apical angle about 60° . Nucleus naticoid, of 2 smooth whorls. Postnuclear whorls 5 in type, decorated with many spiral threads; ribs retractive, making an angle of about 25° with the axis, about twice as thick as the threads; 13 moderately large varices on type. Pillar lip with 3 folds; outer lip with 9 denticulations. Altitude 15 mm.; latitude $8\frac{1}{2}$ mm.

Station 4250, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,940.

Cancellaria jacksonica is very abundant in the Moodys marl member of the Jackson formation at Jackson. It is stouter, more profusely ribbed, and has larger varices and more denticulations than *C. mississippiensis* Conrad, from Vicksburg.

***Olivella jacksonensis* Cooke, n. sp. Fig. 5**

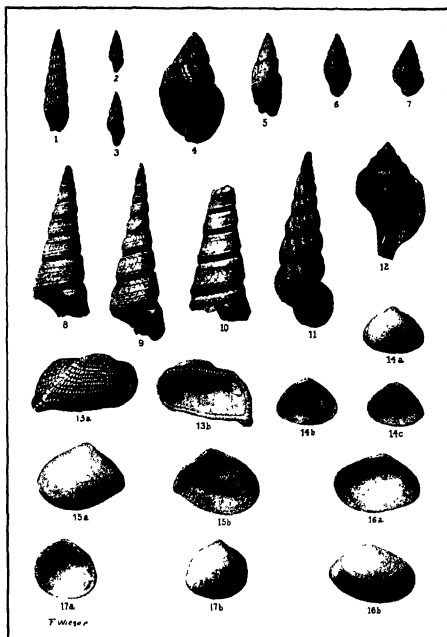
Shell small, spire high, apical angle about 40° . Nucleus spherical, $\frac{1}{2}$ mm. in diameter. Whorls $4\frac{1}{2}$ or 5, slightly convex, suture deep; no deposit of enamel behind the suture. Altitude 11 mm.; latitude 4 mm.; altitude of outer lip $5\frac{1}{2}$ mm.

Station 4250, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,941.

This species is very common in the Moodys marl member at Jackson. Most of the shells are a little smaller than the type. *O. jacksonensis* is similar in general aspect to specimens from the Gosport sand at Claiborne, Ala., labelled *Oliva gracilis* Lea, which are somewhat higher-spined and have larger nuclei. The suture is like that of *O. mississippiensis* Conrad from the Byram marl at Vicksburg, but *O. mississippiensis* is much higher-spined and its nucleus is much larger.

***Conomitra jacksonensis* Cooke, n. sp. Fig. 6**

Shell fusiform, stout, apical angle about 45° . Nucleus small, globular, smooth. Postnuclear whorls $5\frac{1}{2}$, cancellated, turritid; entire whorl except



Figs 1-17.—Fig 12 natural size, all others $\times 2$.

1—*Terebra jacksonensis*; 2—*Drillia dorseyi*, 3—*Pleurotoma juka*; 4—*Cancellaria jacksonica*; 5—*Olivella jacksonensis*; 6—*Conomitra jacksonensis*, 7—*Alcedron jacksonensis*; 8—*Turritella jacksonensis*, 9—*Turritella lovei*, 10—*Turritella rivurbana*; 11—*Epitonium cribrum*, 12—*Levinsus moodiana*, 13—*Barbatta jacksonensis*, 14—*Spisula jacksonensis*, 15—*Tellina vicksburgensis* var. *moodiana*, 16—*Tellina vaughani*, 17—*Cardium gardnerae*.

a narrow band in front of the suture covered with fine, impressed, spiral lines, axial sculpture of close, rounded riblets with interspaces as wide as the ribs, tending to form beads on the sutural band, becoming obsolete near the aperture. Inner lip with 4 strong, straight, parallel folds, outer lip with 14 threads within. Altitude $8\frac{1}{2}$ mm.; latitude 1 mm.

Station 4250, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,942.

This species greatly resembles *Conomitra fusoides* (Lea), but its protoconch is smaller and its sculpture more uniform and more persistent than in the species from Claiborne.

***Alectrion jacksonensis* Cooke, n. sp. Fig. 7**

Shell small, robust, apical angle 50° . Nucleus small, smooth, globular, about 3 whorls. Postnuclear whorls 5, with a narrow band in front of the suture cut into beads by the ribs, area between the band and the periphery crossed by about 4 spiral striae, base of body whorl with spiral threads; axial riblets high, narrow. Outer lip thick, with 6 strong threads within, columella straight, short, with 5 short folds. Canal outcurved. Altitude $7\frac{1}{2}$ mm., latitude 4 mm.

Station 4250, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,943

The type of *Alectrion jacksonensis* is unique.

***Turritella jacksonensis* Cooke, n. sp. Fig. 8**

Shell rapidly expanding, apical angle 25° . Suture impressed. Whorls postero-medially constricted, twice as broad as high, ornamented with faintly nodular spiral threads which continue over the base. Growth lines deeply sinuated on the constriction and gently flexed on the periphery. Altitude 20 mm., latitude 7 mm.

Station 4250, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,944.

***Turritella lowei* Cooke, n. sp. Fig. 9**

Shell slender, apical angle 20° , becoming stouter with increasing growth. First 8 or 10 whorls nearly cylindrical or slightly constricted, later whorls flat. Suture deeply depressed, growth lines sigmoid. Sculpture of faint, spiral threads becoming more conspicuous on larger whorls, many young shells appear almost smooth. One or two whorls broken from tip of type; 12 whorls remaining. Altitude 23 mm., latitude 8 mm.

Station 4250, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,945.

***Turritella rivurbana* Cooke, n. sp. Fig. 10**

Apical angle about 20° . Whorls carinated, slightly constricted medially, suture depressed, spiral sculpture of one strong thread on the carina and several finer, widely spaced threads. Altitude of a fragment of 5 whorls 17 mm., latitude 8 mm.

Station 6466, Town Creek, Jackson, Miss., U. S. N. M. No. 353,946.

In form, this species resembles *T. carinata* Lea from Claiborne, but lacks the crowded, microscopic, spiral threads, its suture is more depressed, and it differs also in the direction of its growth lines. In front of the carina the growth lines of *T. rivurbana* are strongly protractive (bent clockwise to the axis), making an obtuse angle with the lines behind the carina, but in *T. carinata* they are retractive and make an acute angle.

Epitonium cribrum Cooke, n. sp. Fig. 11

Subulate, apical angle about 25°. Nucleus small, of at least 4 smooth convex whorls (broken in type); 10 succeeding whorls moderately convex. Entire surface (including base and varices) covered by fine, close-set, reticulating threads which produce a punctate or sieve-like appearance under the microscope. Axial sculpture of low, rounded, retractive ribs which become fainter on the larger whorls; strong, round, cordlike varices on fourth and seventh whorls and at the aperture; base with one strong cord. Altitude 23 mm.; latitude 8 mm.

Station 4250, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,947.

Levifusus moodianus Cooke, n. sp. Fig. 12

Shell stout, apical angle 75°. Nucleus smooth, whorls rounded (tip broken). Postnuclear whorls $5\frac{1}{2}$, rounded, becoming faintly shouldered, covered with close spiral threads except a bare band on the anterior part of the body whorl. Canal long, straight (tip broken). Inner lip with two low broad folds. Outer lip thin, smooth within (broken). Altitude $31\frac{1}{2}$ mm.; latitude 20 mm.

Station 6458, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,948.

Barbatia jacksonensis Cooke, n. sp. Fig. 13a-b

Shell small, inflated, trapezoidal; beaks at the anterior fourth; with a more or less well defined depression extending from the umbones to the ventral margin; sharply angulated on the posterior slope; posterior border acutely angulated with the base; exterior surface strongly ribbed, the ribs somewhat farther apart on the posterior slope than elsewhere, strongly imbricated in harmony with the lines of growth. Longitude 13 mm.; altitude 8 mm.; semidiameter 3 mm.

Station 6458, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,949.

This species is much smaller than *B. cuculoides*, from the young of which it differs in its greater inflation, stronger ribs, and much coarser and more even imbrication, which imparts to *B. jacksonensis* a cancellated appearance like a tile roof.

Spisula jacksonensis Cooke, n. sp. Fig. 14a-c

Shell small, subovate, moderately inflated; beaks central, adjacent; surface smooth except the dorsal areas, which are wrinkled; anterior dorsal area slightly depressed; base arcuate; pallial sinus little longer than wide, rounded in front; hinge with strong ventral lateral laminae, adjacent sides of laminae striated; arms of cardinal tooth of left valve forming a right angle. Longitude 8.2 mm.; altitude 6.2 mm.; semidiameter 2 mm.

Station 6458, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,950.

The type of *Spisula jacksonensis* is a left valve. This very abundant species differs from *S. funerals* (Conrad) from Vicksburg in its central beaks, more rounded base and shoulders, and in the symmetrical position and rectangular shape of its left cardinal tooth, which in *S. funerals* is twisted forward and forms an acute angle.

Tellina vicksburgensis var. *moodiana* Cooke, n. var. Fig. 15a-b

The variety at Jackson differs from the typical form at Vicksburg in its

larger size, proportionately greater altitude, and slightly stronger sculpture. Longitude $11\frac{1}{2}$ mm.; altitude 8 mm. semidiameter $2\frac{1}{2}$ mm.

Station 4250, Moodys Branch, Jackson Miss. U. S. N. M. No. 353,951.

Tellina vaughani Cooke, n. sp. Fig. 16a-b

Shell subelliptical, beaks slightly anterior, moderately inflated; anterior end somewhat more acute than the posterior; surface covered with close, flat, concentric threads which are fewer, narrower, and farther apart on the dorsal slopes. Longitude $11\frac{1}{2}$ mm.; altitude 8 mm.; semidiameter 3 mm.

Station 4250, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,952.

Cardium (Laevicardium) gardnerae Cooke, n. sp. Fig. 17a-b

Shell small, rather thick, subcircular; entire surface smooth and polished, with faint radial markings; faintly ribbed within; worn shells more or less cancellated, with concentric ridges or wrinkles predominating; original color apparently purple. Longitude $8\frac{1}{2}$ mm.; altitude 8 mm.; semidiameter $2\frac{1}{2}$ mm.

Station 4250, Moodys Branch, Jackson, Miss. U. S. N. M. No. 353,953.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ANTHROPOLOGICAL SOCIETY

591ST MEETING

The 591st meeting was held in the New National Museum October 20, 1925. Dr. JOHN M. COOPER read a paper on *The Têtes de Boule of the upper St. Maurice*, basing his remarks on two visits to them, one in 1916, the other in June, 1925. They are a hunting and trapping people who occupy most of the watershed of the St. Maurice River in Quebec, the northern band straddling at points the Hudson Bay divide. Some of the anthropometrical averages obtained for adult men were: stature, 168.6; cephalic index, 80.67; face breadth, 147.4. The linguistic material gathered seems to show quite clearly that the language spoken is a Cree dialect. The *Têtes de Boule* thus appear as the easternmost Cree. The chief phonetic change is *Tête de Boule* *r* for common Cree *y*. The northern band of the *Têtes de Boule* call themselves *Obidjiwan iriniwāk*, "men of Obidjiwan." They have the typical northeastern family hunting grounds, with inheritance usually in the male line and with use of selection and rotation for conserving the game supply. Marriage is usually patrilocal. Women are well treated. No trace of sib organization or of totemic tendencies was found. The chief has very limited power. There are two assistant chiefs. The chieftaincy is not necessarily hereditary, but actually tends to pass from father to son. Among the adolescent boys and girls, chums are common, but no indication of the gang appeared. Baskets are decorated with spruce root, but the double-curve motive, quill and moose hair ornamentation, and bark etching are absent. Psychically the *Têtes de Boule* are characterized by evenness of temper, good humor, truthfulness and honesty, and socially by marked peacefulness and democratic spirit. The social atmosphere and organization is distinctly non-competitive, even competitive play being seemingly absent.

592D MEETING

The 592d meeting was held in the National Museum, November 17, 1925. Dr ALEŠ HRDLÍČKA addressed a crowded hall on *Ancient man in the far east*. He had just returned from a trip around the world made to study at first hand some of the crucial evidence on primitive man of the past and present. He dealt more particularly with the Rhodesian skull. As a result of his research and observation at the Broken Hill mine, he has been able to clear up many of the uncertainties that have surrounded the discovery of this remarkable specimen. It was found by a miner near the lower end of an old bone- and detritus-filled cave that sloped down from the former surface. The upper part of the cave was largely filled with a great quantity of animal bones, among them a few human remains, and some stone artefacts. The long bones, including the human ones, had been broken or split to extract the marrow. Beyond this part of the cave was a stratum thirty feet thick, of laminated soft lead ore, separating the anterior from the lower posterior section of the cave. The skull of Rhodesian man was found in the lower section, at a depth of 60 feet from the surface. It was not associated with other bones, but not far from it was found a human tibia and a fossil skull of a lion. The bones brought with the skull to England, aside from the tibia, may not belong to the lower part of the cave. These remains are from both male and female skeletons, show varying alteration, and clearly do not belong with the skull. The skull itself was found resting upright and intact without the lower jaw, in a pocket of detritus and "bat" bones, as if put there intentionally. It showed originally no scratches or damage. Below it was found what looked to the discoverers like a roll of mineralized thick hide, and still lower and at some distance the human tibia and lion's skull. The last has apparently disappeared since the discovery. The roll may have been laminated lead ore. It was smelted, as was the mass of mineralized bones from the outer part of the cave. How the skull came to be in such a place at the base of the cave, and who may have put it there, are questions which may never be answered. Nor is it possible at present definitely to classify Rhodesian man among any of the human races of the past or present. The find will probably remain a great anthropological enigma until further evidence bearing on this form of man be discovered.

593D MEETING

The 593d meeting was held on December 15, 1925. Mr W H JACKSON, photographer (1870-79) to the Hayden Geological Surveys, related his *Experiences with the Pawnee Indians 50 years ago*, his address being illustrated with slides from his negatives made in 1868-71. Mr JACKSON crossed the plains to California in 1866, the last year of overland travel by wagon train. Returning eastward as far as Omaha, he went into the business of photography, making pictures of the Indians, frequent visitors to the city, and of their outlying villages, with occasional trips to take views along the completed portions of the Union Pacific Railroad. The Pawnee Reservation, where most of the pictures were made, was on the Loup Fork of the Platte River, about 100 miles west of Omaha. The two principal villages, composed entirely of earthen lodges 30 to 60 feet in diameter, at the eastern end of the reservation, were the ones most frequently visited. Lieut Long, who had passed that way 50 years previously, had estimated the Pawnee there to number 10,000 or more, but disease and constant warfare with the neighbor-

ing Sioux, had reduced them to less than one-fourth of this number. Further aggressions, intensified because of the enlistment of many Pawnees in the army to assist in protecting overland travel, led finally to their removal to the Indian Territory and the entire abandonment of their villages by 1875. Besides detailed views of the villages, typical portraits, and the Industrial School with groups of children, "before and after" illustrations were shown in conclusion of the laborious and complicated "wet plate" process for making photographs 50 years ago

JOHN M. COOPER, *Secretary*.

SCIENTIFIC NOTES AND NEWS

Dr. R. B. SOSMAN of the Geophysical Laboratory, Carnegie Institution of Washington, is giving a continuation of a course of lectures on "Geophysics," begun at the Massachusetts Institute of Technology last year. The general subject of the present series is *Elastic waves and the Earth's structure*.

The Ore Deposits Club met at the Geological Survey on February 19, to discuss the subject of *Zoning of ore deposits*.

The Pick and Hammer Club met at the Geological Survey on February 20. Program: KIRK BRYAN: *Application of geology to archaeology*; T. S. LOVERING: *Organic precipitation of copper*.

Corrigenda.—The following corrections are to be made in the preceding issue of the JOURNAL: p. 88, 14th line from bottom, for "tendon" read "tenon" and for "nearly" read "neatly"; p. 88, 12th line from bottom, the parenthesis should close with "long" and a comma should follow "branch"; p. 91, 9th and 10th lines, read "it appeared that, after becoming loaded with the molecules, they could not pass" instead of "it appeared that the molecules were so crowded that they could not pass"; p. 91, 22d line, strike out "which"; p. 91, 9th line from bottom, read "may" instead of "could".

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 16

MARCH 19, 1926

No. 6

MATHEMATICS.—*A simple formula for welding curves in graduating observational data.*¹ JOHN RICE MINER. (Communicated by RAYMOND PEARL.)

In smoothing data it often happens that a single curve will not fit the whole range satisfactorily and it is therefore necessary to fit different sub-ranges with different curves. As these curves will in general have different slopes at their points of intersection it will often be desirable, in order to avoid the discontinuity in the first derivative that this involves, to use some kind of welding formula which will make a less abrupt transition from the one curve to the other. This may be done by the use of two parabolic segments, each tangent to one of the curves and to the other segment. Let the interval over which the welding formula is to be used be $2n$. We know the ordinate, y_{-n} , and slope, y'_{-n} , of the first curve ϕ_1 at $x = -n$, and the ordinate, y_n , and slope, y'_n , of the second curve ϕ_2 at $x = n$. Our problem is then to find the coefficients of $f_1 = a_0 + a_1x + a_2x^2$ and $f_2 = b_0 + b_1x + b_2x^2$ so that

$$f_1(-n) = y_{-n}, f'_1(-n) = y'_{-n},$$

the condition that f_1 shall be tangent to ϕ_1 at $-n$

$$f_2(n) = y_n, f'_2(n) = y'_n,$$

the condition that f_2 shall be tangent to ϕ_2 at n

$$f_1(0) = f_2(0), f'_1(0) = f'_2(0),$$

the condition that f_1 and f_2 shall be tangent to each other at 0.

¹ Received January 28, 1926. Communication from the Institute for Biological Research of the Johns Hopkins University.

That is

$$a_0 - na_1 + n^2a_2 = y_{-n} \quad (1)$$

$$a_1 - 2na_2 = y'_{-n} \quad (2)$$

$$b_0 + nb_1 + n^2b_2 = y_n \quad (3)$$

$$b_1 + 2nb_2 = y'_n \quad (4)$$

$$a_0 = b_0 \quad (5)$$

$$a_1 = b_1 \quad (6)$$

Eliminating a_1 and a_2 respectively from (1) and (2), and b_1 and b_2 from (3) and (4)

$$2a_0 - na_1 = 2y_{-n} + ny'_{-n} \quad (7)$$

$$a_0 - n^2a_2 = y_{-n} + ny'_{-n} \quad (8)$$

$$2b_0 + nb_1 = 2y_n - ny'_n \quad (9)$$

$$b_0 - n^2b_2 = y_n - ny'_n \quad (10)$$

But from (5), (6), (7) and (9)

$$a_0 = b_0 = \frac{1}{2}(y_n + y_{-n}) - \frac{n}{4}(y'_n - y'_{-n}) \quad (11)$$

$$a_1 = b_1 = \frac{1}{n}(y_n - y_{-n}) - \frac{1}{2}(y'_n + y'_{-n}) \quad (12)$$

and from (8) and (10)

$$a_2 = \frac{1}{n^2}(a_0 - y_{-n} - ny'_{-n}) \quad (13)$$

$$b_2 = \frac{1}{n^2}(b_0 - y_n + ny'_n) \quad (14)$$

As an example we may take the values of $1000q_z$ for material in course of reduction in this laboratory. Up to 57 years these are fitted with¹

$$y = 6.795e^{0.1066x}$$

which at 57 years has an ordinate of 13.449, and a slope of 0.287 per year, while from 63 years up they are fitted with²

$$y = 264 - 113x + 14.4x^2 - 0.48x^3$$

which at 63 years has an ordinate of 26.236, and a slope of 4.541 per year.

Therefore $n = 3$,

$$\begin{aligned} a_0 = b_0 &= \frac{1}{2}(26.236 + 13.449) - \frac{3}{4}(4.541 - 0.287) \\ &= 19.843 - 3.191 = + 16.652 \end{aligned}$$

$$\begin{aligned} a_1 = b_1 &= \frac{1}{3}(26.236 - 13.449) - \frac{1}{2}(4.541 + 0.287) \\ &= 4.262 - 2.414 = + 1.848 \end{aligned}$$

$$a_2 = \frac{1}{3}(16.652 - 13.449 - 3 \times 0.287) = + 0.2602$$

$$b_2 = \frac{1}{3}(16.652 - 26.236 + 3 \times 4.541) = + 0.4488$$

¹ These equations are taken with origin at 25 years and with a five-year interval for the x unit.

The ordinates for the different years are therefore as shown in Table 1.

TABLE 1.—ORDINATES

YEAR	<i>s</i>	1000 <i>v₀</i>
57	-3	13 45
58	-2	14 00
59	-1	15 06
60	0	16 65
61	+1	18 95
62	+2	22 14
63	+3	26 24

SPECTROSCOPY.—*Arc spectrum regularities for ruthenium.*¹ W. F. MEGGERS AND OTTO LAPORTE, Bureau of Standards.

In a preliminary note on this subject the authors described² under-water-spark observations which led to the identification of the lowest term in the ruthenium spectrum. This was a 5-fold term with separations 392.2, 621.7, 900.9, 1190.8 cm.⁻¹, which from analogy with the structure of the iron spectrum was regarded as a quintet-D term. The lack of Zeeman-effect data for the identification of absolute quantum numbers was deprecated and it was announced that new observations were being made in cooperation with Prof. B. E. Moore of the University of Nebraska. The untimely death of Professor Moore interrupted these experiments, but the kind offer of Prof. H. H. Marvin to continue them finally put us in possession of some data. Meanwhile L. A. Sommer in Göttingen has also observed³ some Zeeman patterns for ruthenium lines, and has indicated that the lowest term is in reality a quintet-F term, requiring that all our quantum numbers be increased by one unit. This has been confirmed by our own measurements, some of which appear in Table 2. The purpose of this paper is to make this correction and to extend the analysis of the arc spectrum of ruthenium.

There are presented in Table 1 eighteen multiplets which have been selected as representative of quintet, triplet, and inter-system combinations. The notation⁴ here employed is that which is now in

¹ Published by permission of the Director of the Bureau of Standards of the Department of Commerce.

² Science, 61: 635. 1925.

³ Die Naturwissenschaften, 13: 840. 1925.

⁴ Astrophys. Journ., 61: 60. 1925.

TABLE 1—MULTIPLETS IN THE Ru I SPECTRUM

	$^4F_4$ 1190.8	$^4F_4$ 900.9	$^4F_3$ 621.7	$^4F_3$ 392.2	$^4F_1$
$^3D_4$	3799 34(8)a	3979 44(5)	4127 46(3)		
1194 0	26312 9	25122 1	24221 2		
$^3D_3$		3798 90(8)a	3933 55(4)	4032.21(3)	
969 2		26316 0	25415 2	24793 3	
$^3D_2$			3700 50(10)a	3882 00(3)	3042 06(3)
652 9			26374 3	25752.6	25360 3
$^3D_1$				3786 05(10)a	3843 07(3)
451 1				26405 3	26013.4
$^3D_0$					3777.58(3)a
					26464 5
$^3F_4'$	3728 03(10R)a	3901 24(4)			
1198 7	26816 2	25625 6			
$^3F_4'$	3568 47(1)	3726.93(10R)a	3856 39(3)		
875 5	28015 2	26824 1	25023 7		
$^3F_3'$		3609 10(2)	3730.44(4)a	3819.04(4)	
536 9		27699 9	26798.0	26177 2	
$^3F_3'$			3657 17(2)	3742 29(10)a	3798.06(3)
266.2			27335 8	26714 0	26321.8
$^3F_2'$				3705.36(2)	3760.03(4)
				26980.3	26588.0

TABLE 1—Continued.

	⁴ F ₄ 1190.8	⁴ F ₄ 900.9	⁴ F ₂ 621.7	⁴ F ₂ 392.2	⁴ F ₁
⁴ G ₁	*3498.95(50R) _a 28571 8				
1707 9					
⁴ G ₁	3301 59(8) _a 30279.7	*3436.74(30R) _a 29089 0			
-388.8					
⁴ G ₄	3344.53(3) 29891 0	3483 32(4) 28700.1	3596 17(20) _a 27799 4		
646.2					
⁴ G ₁		3406 59(2) 29346 5	3514 50(3) _a 28445.4	3593 03(20) _a 27823.7	
421 8					
⁴ G ₁			3463 14(3) 28867 2	3539 37(4) _a 28245 5	3589 23(5) _a 27853.2
³ D ₁		3348 69(2) 29853 8	3452 91(3) 28952.8	3528 70(5) 28331.0	
1163 2					
³ D ₁			3319 52(1) 30116 2	3389.50(3) 29494 5	3435 20(3) 29102 1
1372.5					
³ D ₁				3238 77(2) 30867 0	3280 46(3) 30474 7
³ F ₁ '	3294.13(10) _a 30348.3	3428 65(4) _a 29157 7	3537 96(5) _a 28256 9		
2043.6					
³ F ₁ '		3204.04(2) 31201.6	3299.34(2) 30300.4	3368 45(8) _a 29678 8	
780 0					
³ F ₁ '			3216.61(3) 31080 6	(7) 30458.8	3325 00(3) 30066.6

TABLE 1—Continued.

	² F ₁ 1190.8	² F ₂ 900.0	² F ₃ 621.7	² F ₄ 392.2	² F ₅
² G ₁	(7)	3661.34(6)a			
28495.2		27304.6			
1395.9					
² G ₂	3304.81(2)	3440.22(3)	3550.28(3)		
30250.2		29050.6	28158.8		
1902.0					
² G ₃		3260.36(5)a	3350.09(5)a	3430.77(5)a	
		30662.6	29761.5	29139.7	

	² D' ₄ 1092.6	² D' ₃ 608.2	² D' ₂ 436.6	² D' ₁	?	² D' ₀
² D ₄	5309.26(20)	5636.23(35)				
18829.8		17737.5				
1194.0						
² D ₃	4902.73(7)	5280.81(4)	5456.13(8)			
20023.6		18031.2	18322.9			
960.2						
² D ₂		5026.17(8)	5184.72(2)	5304.85(7)		
652.9		19890.3	19282.1	18845.5		
² D ₁			5014.95(8)	5127.25(5)		(?)
451.1			19034.8	19498.2		(?)
² D ₀				5011.22(9)		
				19949.7		

² F ₁ '	5171.02(40)				
19333.2					
1198.7					
² F ₂ '	4809.16(25)	5142.76(8)			
20531.7		19439.4			
875.5					
² F ₃ '	4609.96(8)	4921.08(12)	5072.97(7)		
21407.5		20315.1	19706.8		
536.9					
² F ₄ '		4794.38(4)	4938.43(10)	5047.30(6)	
206.2		20851.9	20243.7	19807.1	
² F ₅ '			4874.33(3)	4980.35(9)	
			20509.9	20073.3	(?)

TABLE 1—Continued.

	$^3D'_1$	1092.6	$^3D'_2$	608.2	$^3D'_3$	438.6	$^3D'_4$	?	$^3D'_5$
$^3G_4$									
1707.0									
$^3G_4$		4385 40(4)							
		22706.6							
-388.8									
$^3G_4$		(?)	4690.11(5)						
		22407.9	21315.5						
646.2									
$^3G_1$		4336 42(2)	4552 10(5)		4981 79(10)				
		23054.0	21961.7		21353.4				
421.8									
$^3G_2$			4466 34(1)	4501 11(6)		(?)			
			22383.4	21775.2	21338.6				
	$^3P_2$	- 727.1	$^3P_1$	1029.2	$^3P_0$				
$^3D_4$		5609 06(20)							
		17541.9							
1194.0									
$^3D_3$		5335 92(10)	5136.55(25)						
		18735.7	19462.9						
969.2									
$^3D_2$		5076 07(5)	4895.28(6)		5155 12(12)				
		19094.8	20422.2		19392.8				
652.0									
$^3D_1$			4743.66(1)		4987.25(5)				
			21074.9		20045.5				
451.1									
$^3D_0$					4877.41(3)				
					20496.7				

TABLE 1—Continued.

	$^1P_1$	— 727.1	$^3P_1$	1029.2	$^3P_1$
$^4F_4'$					
1198 7					
$^4F_4'$	5195.01(10)				
	19243.9				
875 5					
$^4F_2'$	4968 87(7)		4795.57(6)		
	20119.7		20846.8		
536 9					
$^4F_1'$	4839 75(4)		4675 19(1)		4911.58(3)
	20656.5		21383.5		20354.4
266 2					
$^4F_1'$			4617.66(3)		4848 17(2)
			21650 0		20620.6
$^3G_4$					
1707 9					
$^3G_4$					
—388 8					
$^3G_4$	4733.47(12)				
	21120 3				
646.2					
$^3G_2$	4593.08(1)		4444 50(3)		
	21765 8		22493.4		
421 8					
$^3G_2$	4505 64(1)		4362.71(1)		4567 92(1)
	22188 2		22915 1		21885.7

TABLE 1—Continued

	$^3F_4$	1539.4	$^3F_3$	973.4	$^3F_2$
$^3D_3$	4080 63(20) 24499 2		4354 14(5) 22060 2		4546.93(1) 21986 7
1163 2					
$^3D_2$			4144 18(10) 24123 4		4318 43(3) 23150 0
1372 5					
$^3D_1$					4076 75(8) 24522 5
$^3F_4'$	4190 91(10) _a 23803 3		4490 22(3) 22264 4		
2043 6					
$^3F_3'$	3867 82(8) 25847 1		4112 76(8) 24307.8		4284 34(5) 23334 3
780 0					
$^3F_2'$			3084 86(10) 25087 9		4145 75(8) 24114 3
$^3G_4$	4554 52(50) _a 21050 1				
1755.0					
$^3G_3$	4217 28(5) 23705 3		4510 12(8) 22166 2		
1602 6					
$^3G_2$	3950.22(3) 25307.9		4206 02(5) 23768 8		4385.66(4) 22795 2

TABLE 1—*Continued*

	$^3F_4$	1530.4	$^3F_3$	973.4	$^3F_2$
$^3D_4$	5057.33(30) 19767 8		5484 33(10) 18228 7		
1104.0					
$^3D_3$	4769 30(9) 20961 6		5147.24(10) 19422 5		5418.85(6) 18449 0
969 2					
$^3D_2$			4905 01(4) 20381 7		5151.06(8) 19408.1
652.9					
$^3D_1$					4983 44(4) 20060 9
451 1					
$^3D_0$					
$^3F_4'$	4931 72(0) 20271 3				
1198 7					
$^3F_3'$	4656 42(3) 21469.7		5015 99(0) 19930 7		
875 5					
$^3F_2'$	4473.92(4) 22345 5		4804 87(8) 20806.4		5040 74(6) 19833 3
536 9					
$^3F_1'$			4684 02(10) 21343 2		4907 88(8) 20369 8
266 2					
$^3F_0'$					4944.54(9) 20636 0

TABLE 1—*Concluded*

	¹ F ₄	1530.4	¹ F ₃	973.4	¹ F ₂
⁴ G ₄					
1707.9					
⁴ G ₄		4212 08(10) 23734 0			
-388.8					
⁴ G ₄		4282 20(2) 23346 0	4584 45(30) 21806 8		
646.2					
⁴ G ₄		4166 88(3) 23092 1	(7) 22452 9		4654.31(10) 21470 5
421.8					
⁴ G ₄			4370 42(2) 22874 7		4564 69(5) 21901 2

common use for the symbolical description of regularities in line spectra except that the letters S, P, D, F, G are understood to correspond to l values 1, 2, 3, 4, 5, respectively, l representing the quantized sum of the k values of all the individual electrons. The spectral term symbols are shown at the margins together with the separations of the sub-levels. Wave lengths in air, intensity estimates (in parentheses) and wave numbers in vacuum represent the spectral data, the measurements of Kayser⁶ being used from the ultraviolet to 4500Å and those of Meggers⁷ for the longer waves. Because of the larger scale of intensities given by Exner and Haschek⁷ their estimates have been quoted instead of Kayser's. Lines which we have observed as absorbed in under-water-spark spectra are marked *a*; the *raies ultimes* are indicated by asterisks. The present grouping of the higher levels depends, in a few cases, on the rules for spectral line intensities and separations of sub-levels, and since it has been shown that these rules are frequently violated in spectra of the heavier atoms it may be necessary to revise some of the higher level groups when more conclusive data are available. A host of still higher levels has been found but

⁶ *Astrophys. Journ.*, 7: 101. 1898.

⁷ *Bur. Stand. Sci. Pap.*, 30: 20. 1925.

⁷ *Spektren der Elemente bei normalem Druck II*: 212. 1911.

these are reserved until further Zeeman-effect observations permit unambiguous assignment of their l values.

For the purpose of observing Zeeman effects an alloy of ruthenium and platinum was prepared by Dr. E. Wichers of this Bureau. Electrodes of this alloy were supplied to the Brace Laboratory of Physics where the exposures were made, the films being returned to the Bureau of Standards for measurement. Between the wave-length limits 3428 and 4552 Å the Zeeman patterns of 34 ruthenium arc lines were photographed. Most of these naturally involve the low ^4F term since the strongest lines of the spectrum originate with this term. On account of the relatively large quantum numbers the majority of lines are very complex in a magnetic field and are therefore difficult to resolve; only those involving the quantum transition $j \rightarrow j$ between terms of the same l values are simple triplets. Some of the latter and two unaffected lines are listed in Table 2. The separations are expressed

TABLE 2—ZEEMAN EFFECTS FOR RUTHENIUM LINES

λ	COMBINATION	ZEEMAN EFFECT	
		Observed	Theoretical
3726 93	$^4F_4 - ^4F_4'$	(0) 1 36	(0) 1 35
3728 03	$^4F_4 - ^4F_4'$	(0) 1 40	(0) 1 40
3730 44	$^4F_4 - ^4F_4'$	(0) 1 26	(0) 1 25
3742 29	$^4F_4 - ^4F_4'$	(0) 1 05	(0) 1 00
3760 03	$^4F_4 - ^4F_4'$	(0) 0	(0) 0
3777 58	$^4F_4 - ^4D_5$	(0) 0	(0) 0
4112 76	$^4F_4 - ^4F_4'$	(0) 1 16	(0) 1 08
4145 75	$^4F_4 - ^4F_4'$	(0) 0 60	(0) 0 67
4199 91	$^4F_4 - ^4F_4'$	(0) 1 27	(0) 1 25

in terms of a normal triplet; the perpendicular components follow the parallel ones which are enclosed in parentheses. Comparison of the observed and theoretical patterns shows that the Landé⁶ g values are fairly well represented by these particular levels. Considerably larger deviations may be expected for the Zeeman effects of lines involving the higher terms.

The spectral terms for ruthenium, like those for iron, are inverted but the separations of the sub-levels are much larger. After assigning the value zero to $^4F_4$, which is the lowest energy level of the normal ruthenium atom, the relative values of the levels combining to give the multiplets of Table 1 were computed. These relative term values and the corresponding term symbols are presented in Table 3. The

⁶ Zelt. f. Physik, 15: 189. 1923.

interval rule cannot be said to be obeyed by any of these terms although most of the low levels satisfy the rule better than the higher ones. Thus the low ^4F term has separation ratios 5:3.8:2.6:1.6, the higher $^4F'$ has ratios 5:3.6:2.2:1.1, whereas the rule in both cases requires 5:4:3:2. Similarly ^4F has separations in the ratio 5:3.2, and $^4F'$ in the ratio 5:1.9; both should be 5:4 according to rule. Attention is called especially to the irregular intervals 1707.9, -388.8, 646.2, 421.8 in the ^4G term and -727.1, 1029.2 in the ^4P term. In the arc spectrum of iron where, in general, the interval rule is more exactly fulfilled, the strictly analogous terms are also irregular as to their separations. They are -61.5, 474.9, 354.3, 244.8 for ^4G and 176.8, 200.4 for ^4P .

TABLE 3—RELATIVE TERMS IN THE RU I SPECTRUM

$^4F_1$	0 0	$^4D_1$	28466 0
$^4F_2$	1190 8	$^4G_1$	28495 4
$^4F_3$	2091.7	$^4G_2$	28571.8
$^4F_4$	2713 4	$^4F_2'$	28890 7
$^4F_5$	3105 6	$^4D_2$	29118 9
$^4F_6$	6545 0	$^4F_3'$	29427 5
$^4D_1'$	7483 0	$^4D_3$	29570 1
$^4P_1$	8044 0	$^4F_4'$	29693 8
$^4F_7$	8084 4	$^4G_3$	29891 0
$^4D_2'$	8575 6	$^4G_4$	30250 4
$^4P_2$	8771 1	$^4G_5$	30279 8
$^4F_8$	9057 8	$^4F_5'$	30348 5
$^4P_3$	9073.2	$^4G_6$	30537 2
$^4D_3'$	9183 8	$^4G_7$	30959 0
$^4D_4'$	9620.4	$^4D_4$	31044 4
$^4D_5'$	?	$^4G_8$	31853 0
$^4D_6$	26312 9	$^4D_5$	32207.8
$^4F_9'$	26816.3	$^4F_6'$	32392 1
$^4D_7$	27506.8	$^4F_7'$	33172 2
$^4F_{10}'$	28015.2	$^4D_6$	33580 3

From the relative terms recognized in the arc spectrum of ruthenium, we draw the following conclusions as to their characteristic electron configurations. Since the normal configurations of nearly all the atoms in the second half of the fifth period are demonstrated to be of the type $s-1 d$ and one s electrons, we may expect the same for ruthenium also. The low metastable terms found in the Ru I spectrum confirm this, and the presence of $^4D'$ shows also the relatively

* s denotes the number of valence electrons, e.g., 8 for Ru. The notation s, p, d , is used for $5s, 5p$, and $4d$ electrons respectively.

high stability of a configuration of six *d* and two *s* electrons which, as is well known, represents the normal state of the analogous iron atom. The configuration seven *d* and one *s* furnishes the terms ⁴F, ⁴F, ⁴P, ⁴P, ⁴H, etc.; the first three of which have been identified, and parts of a ⁴P are found. There are also indications of another ⁴F term, which must be accounted for by a configuration of eight *d* and no *s* electrons. The higher terms which combine with the terms discussed above, viz., ⁴G, ⁴F', ⁴D, ⁴G, ⁴F', ⁴D, by their occurrence in "triads," reveal their origin as the consequence of the addition of a *p* electron (5₁) to a ⁴F in Ru II. But this ⁴F term is indeed supposed to be the normal state in Ru II, belonging to the configuration of seven *d* electrons.¹⁰ We therefore account for all the higher levels presented in this paper by an arrangement of seven *d* and one *p* electrons.

PALEONTOLOGY.—*Description of remains of an elephant found at Port Williams, Washington.* OLIVER P. HAY, Carnegie Institution of Washington.

From Professor Howard S. Brode, of Whitman College, Walla Walla, Washington, the writer received for examination a part of a collection of elephant remains made several years ago by Rev. Myron Eells at Port Williams, Clallam County, Washington. This place is on the southern shore of the eastern end of the Strait of San Juan de Fuca. The writer has learned nothing regarding the geology of the locality. Professor Brode informs the writer that Rev. Myron Eells was a missionary among the Twana and Clallam Indians for over 30 years. He collected much ethnological material, many fossils, and natural history specimens. He also wrote about 18 books and articles of considerable length.

The collection made by Mr. Eells consists of two third molars, an upper and a lower, which are referred to *Elephas columbi*, a fragment of a skull, which is here described, and tusks, one small and some others of large size. These tusks the writer has not seen. They may belong to *E. columbi* or to the elephant forming the subject of this paper. I regard the skull as belonging to a hitherto undescribed species, and, with the intention of honoring the finder, I name it *Elephas eellsii*.

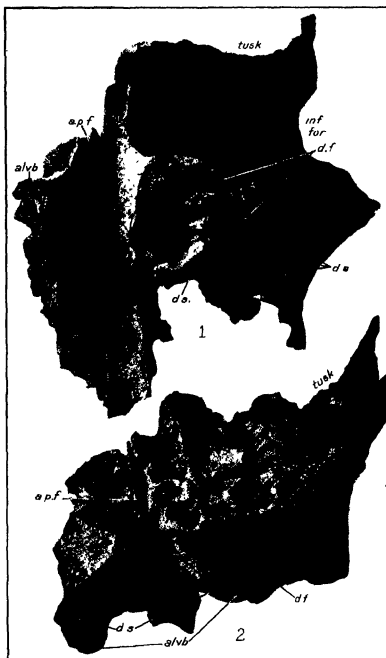
At first view the specimen is an unpromising one. It consists of a part of the left maxilla and a smaller part of the right. The left portion presents the bone from the midline to the outside of the

¹⁰ Kloss and Laporte, Science, 63: 234, 1926.

sheath of the tusk; further backward, to the middle of the infraorbital foramen and the rim of the orbit; thence backward and inward, to the rear of the alveolar border. The palatal portion extends backward to the maxillo-palatine suture. The damaged alveolar border retains sockets for some of the fangs of the teeth. Mesad of the rear of the alveolar border, the palatal portion of the maxilla is missing to within about 28 mm. of the midline. On the right side the palatal border of the maxilla is present a distance of 150 mm., nearly to its union with the palatine bone. Viewed from above the specimen shows a part of the inner surface of the sheath of the left tusk and a multitude of air sinuses.

This fragment of skull presents some characters which the writer has seen in no other elephant. The principal of these is found in the structure of the palate. As in other elephants, there is in front, on each side, a prominent, sharp ridge, the continuation forward of the alveolar border. In the specimen these ridges, where closest, are about 30 mm. apart. Between these points of closest approach and the front of the tooth rows the palate rises about 25 mm. to the anterior palatine fissure, the sloping sides being at an angle of about 80° with each other. A little behind the palatine fissure the downward and outward slope amounts to 73 mm. The result is that, near the front of the tooth row, the midline of the palate is at least 50 mm. higher than its lateral borders. The damaged condition of the bone precludes any definite statement regarding the height farther back. At least, however, the sockets for the fangs of the root become shallower backward, and it is probable that the palate was high and vaulted throughout its length. Its width at the front of the tooth rows appears to have been a little more than 75 mm. The alveolar borders appear to have diverged rapidly backward. Measured from the maxillo-palatine suture to the anterior palatine fissure, the palate is 140 mm. long. Throughout most of this course it is straight along the midline, but as it approaches the palatine fissure it curves upward.

It is difficult to determine much that is certain about the teeth of this animal. On the left side, towards the front, is an opening due to the loss of bone (Fig. 1, inner *d.s.*). Evidently, on both sides, a considerable part of the lower edge of each alveolar border is broken away. On the right side (left in the figure) a depression is seen at the front of this border. This appears to have received the front fang of whatever tooth was present; not, however, necessarily the front root found in a little-worn tooth. On the left side are better indications of the fangs and their sockets. In front is a rough



Figs 1 and 2—Fragment of skull of *Elephas celsi*.
(For description see page 157.)

surface which probably corresponds to the front socket of the right side. The left alveolar border stands about 20 mm. in front of that of the right side, the left tooth being apparently more advanced than the other.

Farther back on the left side, near the outside of the alveolar border, is a socket which retains a fang about 35 mm. long, 18 mm. from side to side, and 11 mm. from front to rear (Fig. 1, *d.f.*, upper guide line). Mesial of this (*d.s.*, upper guide line) is the front and outer wall of another socket. Just behind these is another pair of sockets, the outer one shallow, the inner one 50 mm. deep. Still farther in the rear, on the outer side of the alveolar ridge, is another fang in its socket (*d.f.*, lower guide line). The lower guide line of the inner *d.s.* leads to what is apparently a partial socket, paired with the outer one containing the fang. Between the two is a hole which is apparently factitious. From this opening, a ridge, smooth on its steep front and its sloping rear, runs inward and backward. Behind the ridge is another partial socket (lower *d.s.*). The writer concludes that probably the alveolar border of each side bore a second molar tooth, that the partial socket in front, on the right side received the larger inner front root and that on the left side the partial socket is the scar left by the absorbed outer front root. The other sockets and the snags belonged apparently to three pairs of small fangs. Between the hinder pair of these and the great hinder root was a notch which was occupied by the outer end of the transverse ridge above described.

In elephants there is usually, on each side, between the alveolar border and the base of the sheath of the tusk, an excavation, or fossa, of little depth. In the specimen under consideration the front of the alveolar border rises perpendicularly about 70 mm. to the summit of the fossa and then curves outward and upward to the front of the infraorbital foramen. In a specimen of *Elephas primigenius* found many years ago at Pastolik, Alaska, by Dr. W. H. Dall, the roof of this

Fig. 1.—Specimen seen from below $\times 0.4$. *alb*, alveolar border, *a p f*, anterior palatine fissure; *d.f.*, dental fang, *d s*, dental socket; *inf for*, infraorbital foramen. The line from *alb* traverses the front socket of a part of the root of the tooth. It ends at the summit (as seen from below) of the alveolar border. On the opposite side the corresponding point is in front of the anterior fang indicated by *d.f.* In front of *d.s.*, upper guide line, are seen indications of the foremost socket of that side.

Fig. 2.—Specimen seen from in front and below abbreviations as in Fig. 1: *d s*, the guide-lines run to the right and left anterior sockets; *d.f.*, indicates the first fang present. In this figure the smooth surface just below the word "tusk" was in contact with the tusk; elsewhere are seen the air sinuses.

fossa extends outward nearly horizontally beneath the sheath and curving around meets at nearly a right angle the lateral face of the sheath just in front of the infraorbital foramen. In the Alaska specimen the lower border of the foramen is only about 90 mm. above the front end of the alveolar border; in the Port Williams skull the corresponding distance is about 120 mm.

Of the sheath of the tusk there remains only the lower and outer part of its base. It is estimated that the diameter of the tusk was about 4 inches. Of the bone in actual contact with the tusk there is left only a patch 90 mm. long. This is seen in figure 2 of the plate just below the word "tusk." The removal of the rest has exposed the air cells between the inner and outer layers of compact bone.

The writer finds that the different species of elephants, so far as he has examined them, have each a form of palate more or less different from that of other species. The palate of the African elephant is broad behind and narrows rapidly forward. From front to rear it is slightly concave. From side to side it is concave, but the concavity may be interrupted by a low median ridge. In the Indian elephant the palate is somewhat convex from front to rear, but there may be at one or both ends a short concavity. From end to end it is traversed by a prominent median ridge, on each side of which is a groove. Cross-sections, therefore, present right and left concavities. The alveolar borders are more nearly parallel than they are in the African species.

The elephant brought by Doctor Dall from Pastolik has a peculiar palate. Between the anterior palatine fissure and the front of the teeth it is strongly concave; in the space between the front ends of the alveolar borders the palate is flat; farther back it becomes strongly convex as far as the maxillo-palatine suture. From end to end, then, the palate presents a pronounced sigmoid curve. At the front of the flat portion a median ridge begins which increases in height backward. In front the alveolar borders are on a level with the palate, but backward they descend, so that near the maxillo-palatine suture they are 35 mm. below the palate. In this region there is, therefore, a broad, deep groove on each side of the palate.

In the U. S. National Museum is a fine skull of *Elephas primigenius* from Siberia. It is mounted for exhibition and the iron supports conceal the palate to such an extent that a view of it can hardly be obtained; but so far as can be determined, the palate is like that of the Pastolik specimen.

In his work on the frozen elephant found in Beresovka River, Siberia,¹ Dr. W. Salensky furnished a figure of the skull as seen from below. The palate, as seen in that figure, presents no such construction as does that of the Pastolik specimen. It appears to have been quite flat from end to end and from side to side. The Pastolik animal has a palate only about 60 mm. wide, with the sides parallel. The Beresovka elephant's palate appears to be 80 mm. wide in front and wider behind. These deviations from the palate of *E. primigenius* appear to confirm the writer's conclusion arrived at in 1922² from the thickness of the plates of the teeth that Salensky's elephant did not belong to *E. primigenius*, but was then an unnamed species. This was accordingly called *Elephas beresovkii*.

In the U. S. National Museum is the type of *Elephas boreus*. As in the case of the Siberian specimen the iron supports prevent any determination of the structure of the palate. It is possible that the method of mounting the skull of the great elephant of the same species in the American Museum of Natural History, at New York, will permit an examination of the palate. This elephant was found in Indiana and is nearly complete. It is worthy of being regarded as the plesiotype of the species *Elephas boreus*.

In the U. S. National Museum is a part of a skull of *Elephas imperator* from an unknown locality. It presents the palate and the two fine hindmost molars. From the anterior palatine cleft to the rear of the palate the midline is nearly straight. This, however, is the crest of a prominent ridge, low in front, but increasing in height to the maxillo-palatine suture, then decreasing. On each side of this is a groove whose depth at the suture mentioned is quite an inch. The borders of the palate descend somewhat below the median ridge. The length of the palate is 12.5 inches; its width at the rear, 4.5 inches.

A specimen of an elephant found at Buckeye, Matagorda County, Texas, whose teeth indicate *E. imperator*, has a palate much like the one just described, as is shown by a cast sent me by Dr. Mark Francis. A photograph of the palate of *Elephas roosevelti*, as represented by a palate and teeth at Milwaukee, shows so much at least that its palate is different from that of *Elephas cellsi*. I have not had the opportunity to examine the palate of *E. columbi*.

¹ Scientific Results, etc., 1903, pl. VI, fig. 45

² Observations on some extinct elephants, p. 4.

BOTANY.—*New South American species of Rubus.* ALWIN BERGER,
New York State Agricultural Experiment Station, Geneva, N. Y.
(Communicated by A. S. Hitchcock.)

The United States National Herbarium is rich in South American material of the genus *Rubus*, the extensive collections of J. N. Rose, A. S. Hitchcock, F. W. Pennell, and E. P. Killip having been recently added to it. In view of the investigations which I have been carrying on in this genus all of this material was sent me, and I have thus had an opportunity for thorough study. Although convinced that the collection contains several new species and forms, I hesitate to describe more than the following.

***Rubus gachetensis* Berger, sp. nov.**

Rami floriferi teretes, breviter dense griseo-tomentosi aculeis parvis sparsis recurvis armati; rami steriles desunt. Stipulae ovatae, obtusae. Folia ternata, suprema subtriloba vel simplicia; petioli 1 cm. longi, tomentosi, parce aculeati petiolulus medius fere aequilongus; foliola obovata, obtusa, coriacea, supra glabra nitidula vel minute puberula, subtus griseo-tomentosa, in costa media parce aculeata, costis lateralibus utrinque 6, (5-7) margine recurvulo inaequaliter crenato-serrata, foliola terminalia, 4-5 cm. longa, 3 cm. lata. Ramuli floriferi axillares et terminales 3-5-flori; pedicelli 1-3 cm. longi, villosi-tomentosi, aculeis recurvis armati. Calyces tomentosi, sepalis ovato-deltoides 6 mm. longis, petala duplo longiora rubra.

COLOMBIA: Camino de Gachetá, in forests, alt. 2300 m. *Brother Aristoe-Joseph* A543.—Flowering, January 1920. (Type, U. S. National Herbarium, no. 1,059,773.)

Species subgeneris "*Orobatus*" Focke, *Rubo mandonii* affinis, differt foliis coriaceis, obtusis, paucinerviis etc.

***Rubus choachiensis* Berger, sp. nov.**

Fruticosus, ut videtur decumbens. Rami teretes, ut petioli, petioluli etc. dense tomentosi aculeisque minutis recurvis parum numerosis asperi. Folia ternata. Stipulae magnae ovatae, acutae, integrae vel subcrenulatae. Petioli 3-4 cm. longi, petioluli terminales 15 mm. longi, laterales brevissimi. Foliola crassa, obovato-oblonga, basi rotundata, breviter acuta, utroque latere nervis 8-10 percursa, supra obscure viridia velutino-pubescentia, subtus densissime incano-tomentosa, costula media aculeata, margine subaequaliter crenato-serrato, terminalia 5-8 cm. longa et 4 cm. vel ultra lata, in ramis floriferis minora obtusiora. Flores 3-4 in ramulis lateralibus racemosi; pedicelli 10-13 mm. longi ut calyces dense tomentosi, aculeolis sparsis armati. Sepala orbiculari-ovata, cuspidata, 7 mm. longa et 8 mm. lata; petala longiora pulchre coccinea.

COLOMBIA: Dept. of Cundinamarca, Paramo de Choachi, near Bogotá, alt. 3700 m. —"Low shrub, flowers deep red." *E. P. Killip & Brother Aristoe-Joseph* 11967.—Flowering, August 8, 1922. (Type, U. S. National Herbarium, no. 1,140,050.)

Species ex subgenere "*Orobatus*" Focke, affinis *Rubo weberbaueri*, differt autem habitu robustiore, tomento eglanduloso, calycis lobis late ovato-deltoides.

Rubus roseorum Berger, sp. nov.

Fruticosus. Caules floriferi teretes, brunnei, puberuli, aculeisque recurvis complanatis armati alisque setiformibus sparsis asperi, superne ut petioli, pedunculi etc. glandulis stipitatis confertis vestiti. Folia inferiora quinata, superiora ternata, floralia simplicia; stipulae subulatae; petioli 5-6 cm. longi, dense glandulosi, aculeisque 3-4 recurvis armati; petioluli consimiles, terminalis circ. 15 mm. longus. Foliola oblongo-lanceolata, breviter acuminata, basi rotundata vel vix cordata, terminale 6-7 cm. longum et ultra 3 cm. latum, lateralia minora, membranacea, costularum mucronibus dentibusque interjectis serrulata, costulae laterales 10-12, utrinque glabra, costulis tamen puberulis. Inflorescentiae terminalis inferne foliferae rami pedicellique albo-villosi glandulisque stipitatis brunneis muniti. Sepala ovato-deltoides, utrinque albo-tomentosa glanduligera, petalis albis oblongis dimidio breviora.

ECUADOR: Vicinity of Quito. *J. N. Rose & George Rose* 23548. Flowering and fruiting, October 26 to November 1, 1918. (Type, U. S. National Herbarium, no 1,023,038) Chillo Valley; Santa Rosa, alt 9600 ft. *H. E. Anthony & G. H. H. Tate* 204. Fruiting, August 26 to September 2, 1923.

Eubatus e grege *Adenotrichorum* Rydb. Frutex ut videtur e humilioribus, caules steriles adhuc ignoti.

I take pleasure in naming this species for Dr. J. N. Rose and his son, Mr. George Rose, who accompanied his father in 1918 to South America, and who always showed a great interest in plants, and did much good work.

Rubus killipii Berger, sp. nov.

Fruticosus. Rami floriferi teretes, minute tomentelli demum glabrescentes, aculeis raris vel deficientibus. Folia ternata; stipulae subulatae; petioli 6 cm. longi, minute tomentelli aculeisque nonnullis falcato-recurvis sat robustis armati; petiolulus terminalis 3 cm. longus, laterales 5 mm. longi. Foliola oblonga, utrinque rotundata, apice abrupte acuminata, coriacea, dura, glabra, supra nitidula obscure viridia nervis impressis tomentosulis, subtus pallidiora costaeque aculeata, utrinque nervis lateralibus 8-10 rectangulariter patentibus prominentibus minute puberulis percursa, secus margines dentibus parvis minute mucronatis remote serrata; foliolum terminale circa 12-13 cm. longum et 9 cm. latum. Inflorescentiae amplae eximie multiflorae rami inferiores axillares circa 40 cm. longi, ut pedunculi pedicelli calycesque dense tomentosi. Pedicelli 1 cm. longi, bracteis deltoides vel lanceolatis tomentosis muniti; calycis lobi ovato-deltoides breviter cuspidati, 5-7 cm. longi reflexi; petala obovata obtusa 12 mm. longa rosea; stamina numerosa, carpella tomentosa.

COLOMBIA: Department of El Cauca, "La Gallera," Micay Valley, Cordillera Occidental. Clearing near Rio San Joaquin, alt. 1100-1300 m. "Shrub, petals pink." *Ellsworth P. Killip* 7835. Flowering, June 29-30, 1922. (Type, U. S. National Herbarium, no. 1,142,423.) "The place where I collected this was about the most isolated imaginable, away down in the southwestern corner of Colombia. Two new genera and a number of new species have been found among these specimens." (E. P. Killip.)

Frutex ut videtur altus, copiose ramosus, floribundus et praepulcher, ex affinitate *Rubi florulenti*, Portoricensis plantae, sed robustior in omni parte, caulibus minus aculeatis, et foliis floribusque majoribus.

I take great pleasure in naming this species for Mr. E. P. Killip who has done so much for the exploration of the Colombian flora.

RADIO-TELEGRAPHY.—*Application of radio transmission phenomena to the problems of atmospheric electricity.*¹ J. H. DELINGER, Bureau of Standards.

My remarks are in the nature of a brief progress report on the inter-relations of the problems of radio transmission phenomena and those of atmospheric electricity. While there is no novelty in the idea of this inter-relation, it having been prominently in the minds of many workers in both fields for years, it nevertheless does appear that recent radio developments will shed considerable light on the things with which the student of atmospheric electricity concerns himself. I hasten to say that the applications of the radio phenomena, which I have in mind, are applications to the underlying rather than to the immediate problems of atmospheric electricity and terrestrial magnetism. From the beginning of their study, the seat of the phenomena of atmospheric electricity has been obscure and it is becoming increasingly plain that the phenomena of radio wave propagation are attributable to the same seat. Indeed, I could equally have entitled my remarks "Application of atmospheric-electric phenomena to the problems of radio transmission."

There are two reasons for putting it the way I did, one having to do with the mode of conducting work in this field, and the other having to do with the question of who is to analyze and interpret the results. On the first point it is apparent that radio gives us a direct means of conducting controlled experiments on phenomena affected by the electrical conditions of the atmosphere, a means which is wholly impossible in the field of direct atmospheric-electric measurements. These means are being abundantly used; as you all know, radio experimentation is becoming very widespread and its results are increasingly fruitful. We are learning to select radio wave transmissions in particular directions, at particular times, and on particular frequencies, such as to produce an effect conditioned in a definite way upon electrical conditions in the atmosphere. Organization of such work is proceeding, from the sporadic work of the individual, to organized effort on a large scale. The second reason which I mentioned as determining the viewpoint chosen for this discussion, is simply that atmospheric electricity, rather than radio, is the science which must take the responsibility and the labor of deciphering the inner

¹ Presented before Section of Terrestrial Magnetism and Electricity, American Geophysical Union, April 30, 1925. Published by permission of the Director, Bureau of Standards.

relations between these various phenomena and the deduction of the underlying causes thereof. I shall return to this point later, and hope to justify it.

After much study of the available data and consideration of possible causes, radio science now considers that the major phenomena of radio wave transmission have their origin in the stratosphere. From the beginning of radio there have been efforts to find connections between characteristic radio transmission conditions and weather. By and large, the conclusion may now be stated that the effects of weather are minor in comparison with the effects of atmospheric electricity. Stated in another way, the major radio phenomena occur in the stratosphere rather than in the troposphere. I would not give the impression that weather conditions are entirely without effect on radio phenomena; if I were to make a comprehensive discussion of my subject I would be inclined to add to the title the words "and meteorology." However, the weather-radio phenomena are less definite and less certainly proved. For example, there is some indication that the strays or atmospheric disturbances of radio have some definite relation to maxima of pressure gradients as determined meteorologically, but in comparison with this tentative conclusion, slenderly supported, the evidence on the other hand is overwhelming that all radio-atmospheric disturbances have their origin in some form of atmospheric-electric discharges. C. T. R. Wilson's recent theory indicates that these discharges may not necessarily be lightning, but may, in large measure, be discharges taking place above the clouds. Here we see that the most likely explanations even of atmospheric phenomena can not neglect causes in the stratosphere.

The vagaries of radio wave transmission are so well known as to need no summarizing. The citizen listening to a broadcast program feels cheated when the signal intensity variation known as fading spoils his program. He is puzzled by the reports he hears that transmissions carried on with very high frequencies at certain times of day accomplish with very small power results which are impossible with very large power on the low frequencies. He is inclined to be impatient with the scientists and engineers because they can not eliminate these fluctuations and anomalies. Studies made during the past year and now still in progress are leading to a very considerable degree of understanding of these phenomena. The causes of the vagaries are pretty definitely localized in the stratosphere and are certainly closely tied in with the phenomena of atmospheric electricity. I shall

not attempt, in my few minutes, to summarize the behavior of high radio frequencies. Both popular and technical magazines are full of data and speculation on the subject.

Suffice it to say that these phenomena have thoroughly established the hypothesis proposed by Eccles in 1912 (and developed by Kennelly and others) which explain the great differences of distance of radio transmission at night and in the day by the daytime ionization of the air caused by the ultra-violet light in the sun's rays. The removal of this cause of ionization at night clears up the lower atmosphere so that the waves can penetrate to high altitudes at night. At some level in the atmosphere there must be a pressure so low that the permanent ionization above this level will render the medium conducting, thus providing something of the nature of a surface along which the waves can glide at night. Turbulence of the medium near this surface explains^{*} fading (i.e., intensity fluctuations). A theory definitely worked out by Larmor during the past year has more firmly established this theory by showing that the effect of the interaction of the radio wave with the ionized particles leads to a bending down of the waves, thus establishing a calculable quasi-refraction which gives a real physical picture of the wave transmission and is a great advance over the conception of a wave sliding along a hypothetical conducting surface. Machinery of a very reasonable sort is thus established for the wave propagation.

This theoretical work comes simultaneously with the experimentally established facts of propagation of very high frequency waves without appreciable absorption, such remarkable effective propagation being observed even in the daytime when the frequency is sufficiently high. The remarkable thing about the Larmor theory is that it permits an explanation of new phenomena which had not hitherto been suspected, and enables a determination of the approximate height in the atmosphere of levels of various degrees of ionization from the observed effects of radio transmission in terms of the frequency, times of day, and other known factors of the transmission. I think it is sufficiently well known to you that with the very high frequencies there is a zone relatively near the transmitting station in which the waves can not be received at all but that beyond this zone they come in very effectively. An analogy which I like to use for the mechanism of transmission of radio waves is that of the German long range gun which bombarded

^{*} *Radio signal fading phenomena.* J. H. DELLINGER and I. E. WHITTEMORE. THIS JOURNAL, 2, p 243. June 4, 1921.

Paris at a distance of 60 to 80 miles. The rarefied higher portions of the atmosphere which permitted the projectile to fly toward Paris with little resistance has a remarkable similarity to the atmospheric electric strata which, by their particular conditions of ionization, permit radio waves of a particular frequency to travel enormous distances around the earth.

This very fruitful theory is being supplemented by a very recent addition made by Messrs. Nichols and Schelleng of the Bell Telephone Laboratories and by English physicists, in which they have definitely worked out the additional effects caused by the interaction of the earth's magnetic field with the motions of the ionized atmospheric particles set up by the passing radio wave. Eccles had previously used the same theory to explain the variations of radio wave direction. This remarkable addition to the explanation of this phenomena is only a month old and it shows that some things, such for example as the predominance of radio fading at certain frequencies, are closely tied in with the effect of the earth's magnetic field as well as the differing ionization at various levels in the atmosphere.

I feel that I am speaking in generalities but that more specific explanation of the trend of current theory as well as the revelations of experiment would require very much more time than is at my disposal. Before I close I want to warn you against a number of current theories or, let us say, ways of referring to these radio phenomena, which are more or less in error. The first of these is the explanation of all these phenomena in terms of an alleged "Heaviside layer." Related to this is the ascribing to Heaviside of the current explanations of radio wave propagation phenomena. Heaviside did not know much about the phenomena of radio wave propagation and did not postulate a layer. What he did do was very valuable and still stands, namely the suggestion that at a certain height in the atmosphere a surface can exist, at which there is a greater or less discontinuity of conductivity, and that this can affect and assist the propagation of radio waves. Beyond this he did not go, and it seems to me that the expression "Heaviside surface" is in accordance with Heaviside's ideas but that the expression "Heaviside layer" is not. Since, furthermore, the recent theories of Larmor and of Nichols lead to the existence of numerous levels rather than a single level in the atmosphere which facilitate the propagation of waves at particular frequencies, even the expression "Heaviside surface" is no longer very useful.

Another misconception or instance of loose thinking is the ex-

planation of the wave propagation as reflection. I do not say that reflection may not eventually be established as the proper explanation, but the evidence is that the waves are guided by a conducting surface and that their propagation is in large part explained by a quasi-refraction caused by the interaction of the radio field intensity and the velocities of the ionized particles. Reflection in the true sense is not an accurate description of any phase of this process.

Another theory which I cannot accept and which is closely tied to the reflection theory is that the differing characters of propagation at different frequencies are due to differing heights of the strata which are effective; that is, the popular idea conceives the waves of varying frequency or wave lengths to be shot out from the transmitting antenna and that certain of them are reflected from a sort of sky mirror located at one height, and those of another frequency or wave length from a different sky mirror at a different height. These strata of differing conductivity doubtless exist and exist at different heights, but the phenomena which result are almost certainly not due to the difference in height of the strata but to the difference in character, that is, differing ionization and ionization gradient.

If I may be pardoned for still another attack on what I believe to be misconceptions I will refer to the rather free use of the idea of interference (as between light waves) as explaining fading. This again is tied in with the conception of propagation by reflection. Now it is almost inconceivable that the effective atmospheric strata are so uniform as to permit reflection of the uniform character that would be required to produce interference like that in optics, or that individual conditions of interference would not be statistically averaged out. The nature of the phenomena is such that the more probable explanation of the received intensity fluctuations is variable absorption in the medium caused by turbulence in the ionized strata. The result of this is that the wave arriving at a given receiving point is really a complex of waves from different directions, with differing intensities, phases, and polarizations. Variation in the air path of any part of this complex appears to the observer as a change in the resultant received wave. There is only one recorded instance that I know of which looks like genuine interference of optical type, and that is a series of remarkably regular fluctuations in received signal intensity obtained at the sunset period by five observers cooperating with the Bureau of Standards in some sunset transmission tests which closed on the 2nd of this month.

I would list the specific applications or inter-relations of radio phenomena and those of atmospheric electricity as in Table 1.

TABLE 1 -- INTER-RELATIONS

ATMOSPHERIC ELECTRICITY	RADIO PHENOMENA
Lightning and thunder clouds Aurora and magnetic storms	Atmospheric disturbances Radio and electric line telegraph disturbances
Atmospheric potential gradient, and conductivity; diurnal and annual variations	Similar variations in atmospheric disturbances and field intensities
Earth's magnetic field and upper air conductivity	Differing radio wave propagation at various frequencies, distances, and directions

Summarizing, it is abundantly evident that the vagaries of radio transmission phenomena have an application to the problems of atmospheric electricity and terrestrial magnetism. In the latter field, fundamental explanations must make use of a system of currents in upper atmospheric strata which are subject to daily variations of ionization. In radio, we have a tool with which we can actually explore these strata and determine some of the facts having direct bearing on atmospheric electricity and the earth's magnetic field. Radio must leave to the science of atmospheric electricity the duty of deciphering the inter-relations between the two fields and applying them to the determination of fundamental causes. There are two reasons for this, first, radio is too fully engrossed with the determination of the immediate facts and applying them to the numerous important uses which are at hand, and second, there is no reason why radio should be concerned with going back of the immediate causes of the wave phenomena. The radio scientist will be happy indeed to get a reasonable picture of the wave transmission mechanism. He is not at all concerned with whether this mechanism is due to particles shot directly from the sun, cosmic dust, radioactive material in the air or soil, penetrating radiation, currents below ground, or lightning. A complete picture of the ionized strata in the atmosphere directly affecting his transmitted waves will satisfy him very well, and the deeper insight into the cause of this ionization and its characteristics he leaves to the worker in the larger field of atmospheric electricity.

SCIENTIFIC NOTES AND NEWS

An expedition to Africa to collect living giraffes, rhinoceroses, and other animals for the National Zoological Park will sail from New York March 20. The funds for the work have been presented to the Smithsonian Institution by WALTER P. CHRYSLER. The Expedition will consist of W. M. MANN, Director of the National Zoological Park, ARTHUR LOVERIDGE of the Museum of Comparative Zoology at Cambridge, Mass., and STEPHEN HAWES, artist, and will be accompanied by CHARLES CHARLTON, of the staff of the Pathe News.

The Petrologists' Club met at the home of F. E. WRIGHT on March 2. Program: T. S. LOVERING, *The need of certain physical constants in physical chemistry*; C. S. ROSS, *Replacement of igneous rock minerals in sedimentary beds*; A. C. SPENCER, *Alteration of plagioclase to sericite plus quartz*; F. E. WRIGHT, *The new geological map of South Africa*.

W. R. SMITH has resigned as geologist in the Alaska Branch of the U. S. Geological Survey.

SIDNEY PAIGE, chief of the Areal Geology Section of the U. S. Geological Survey, has accepted an engagement with the Amerada Corporation for work in South America.

G. N. COLLINS and F. E. KEMPTON sail March 17 for Haiti for the purpose of inaugurating experiments with perennial teosinte (*Euchlaena perennis*) and teosinte-maise hybrids. They plan to remain five or six weeks and cover the region between Port au Prince and Cape Hatien.

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

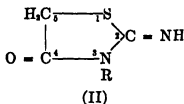
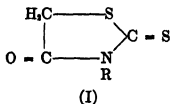
VOL. 16

APRIL 4, 1926

No. 7

CHEMISTRY.—*The condensation of aldehydes with diphenyl isothiohydantoin.* RAYMOND M. HANN and KLARE S. MARKLEY,¹ George Washington University. (Communicated by EDGAR T. WHERRY.)

In continuing the series of researches upon rhodanic acids now being pursued in this University it became a matter of interest to study, comparatively, the reactions of compounds possessing an analogous constitution. Rhodanic acids are the cyclic anhydrides of the dithio-carbamo glycollic acids and may be considered as 2-thio-3-alkyl (or aryl)-4-thiazolidones (I), while the isothiohydantoins are cyclic anhydrides of substituted thiohydantoic acids and may be classed as 2-imino-3-alkyl (or aryl)-4-thiazolidones (II). The close similarity in structure of these compounds has led us to prepare a



number of derivatives of 2-phenyl-imino-3-phenyl-4-thiazolidone.² Diphenyl isothiohydantoin or 2-imino-phenyl-3-phenyl-4-thiazolidone has been prepared by Lange,³ and further studied by Lange and Liebermann,⁴ who showed that its reduction with alcoholic potassium

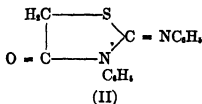
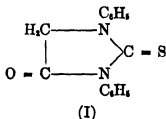
¹ Presented before the meeting of the American Chemical Society, Los Angeles, California, Aug. 3-8, 1926.

² Numbering is according to the recommendation of BOBERT and ABRAHAMSON (Journ. Amer. Chem. Soc. **44**: 826. 1922) taking the sulfur atom as 1.

³ LANGE Ber. Deutsch. Chem. Ges. **12**: 505 1879.

⁴ LANGE and LIEBERMANN. Ann. Chem. **207**: 123. 1881, see also ANDREASCH. Ber. Deutsch. Chem. Ges. **12**: 1835. 1879.

hydroxide yielded thioglycollic acid and diphenylthiourea. This decomposition and other substantiating facts led them to revise the original structure proposed by Lange (I)



and substitute the pseudo-thiohydantoin structure (II).

The later structure includes the S-CH₂-CO linkage which has been pointed out by various workers to be a very reactive grouping. Among the compounds which react with the methylene hydrogen in such a combination may be mentioned the aldehydes,⁸ isatin,⁶ formamidines,⁷ alloxan,⁸ phthalic anhydride,⁹ and phenanthraquinone.¹⁰

The present paper describes the preparation and properties of a series of aldehyde condensation products of diphenyl isothiohydantoin.

EXPERIMENTAL

*Diphenyl isothiohydantoin.*¹¹—The parent substance was prepared from diphenylthiourea and monochloroacetic acid according to the method of Lange.¹² The yield calculated on the basis of diphenylthiourea used, was 60 per cent of theory.

3,5-Dichloro-salicylic aldehyde.—Twenty grams of salicylic aldehyde was dissolved in 80 grams of glacial acetic acid and a stream of dry chlorine allowed to bubble through the solution as it was gently heated on the steam bath. Following saturation with the halogen the solution was cooled and a stream of cold water added to cause precipitation of the substituted compound. After filtering by suction the derivative was recrystallized from dilute alcohol. The yield was 25.3 grams.

⁸ WHEELER and JAMIESON. *Journ. Amer. Chem. Soc.* **25**: 366. 1903.

⁹ HILL and HENZE. *Ibid.* **46**: 2806. 1924.

⁷ DAINS and STEPHENSON. *Ibid.* **38**: 1841. 1916.

⁶ BUTSCHER. *Monats für Chemie* **32**: 9. 1911.

⁵ KUCERA. *Ibid.* **35**: 137. 1914.

¹⁰ HANN. Unpublished results.

¹¹ This substance has been prepared by DIXON and TAYLOR (*Journ. Chem. Soc. London* **101**: 501. 1912) from *n*-phenyl-*u*-carbethoxy phenylthiourea and chloroacetyl chloride.

¹² LANGE. *Ber. Deutsch. Chem. Ges.* **12**: 595. 1879.

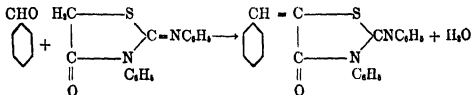
3-Methoxy-4-hydroxy-5-chloro benzaldehyde.—Vanillin was dissolved in glacial acetic acid and a small amount of fused sodium acetate added. Dried chlorine was then lead in, substitution taking place with rise in temperature of the solution and evolution of a slight amount of hydrochloric acid gas. As the reaction continued brilliant colorless crystals separated. Following saturation the crystal meal was filtered off and recrystallized from glacial acetic acid. The chloro-vanillin crystallizes in the tetragonal system and melts at 104–5°C.

3-Methoxy-4-hydroxy-5-nitro benzaldehyde.—Vanillin was nitrated in the cold with fuming nitric acid according to the directions of Bentley.¹³ The nitrated compound may be separated from small amounts of side reaction products by recrystallization from alcohol.

3-Methoxy-4-hydroxy-5-bromo benzaldehyde.—Vanillin was brominated according to Dakin's¹⁴ directions, the bromo-aldehyde separating in pure condition from the reaction mixture.

Aldehyde condensation products

5-Benzal-2,3-diphenyl isothiohydantoin.—Dissolved 3 grams of diphenyl isothiohydantoin and 1.2 grams of benzaldehyde in 25 cc. of glacial acetic acid and after adding 5 grams of fused sodium acetate refluxed the mixture for 2½ hours. After cooling an excess of water was added to the reaction mixture, the precipitated condensation product was filtered off, recrystallized from acetic acid and analyzed. The yield was 3.6 grams. Theory 3.98 grams. The reaction was as follows:



5-Benzal-2,3-diphenyl isothiohydantoin is a solid, crystallizing in brilliant platelike crystals of a slight yellow color. It melts at 215–6°C. (cor.).

¹³ BENTLEY. Amer Chem Journ **24**:172. 1900.

¹⁴ DAKIN. Amer. Chem Journ. **42**:477 1909.

Analysis (Boric acid method)¹⁴

0.2095 gm. consumed 16.3 cc. $\frac{N}{14.01}$ acid, equivalent to

7.78% N. Theory for $C_{22}H_{11}ON_2S$ is 7.86% N.

5-(o-Nitro-benzal)-2,3-diphenyl isothiohydantoin.—The substitution of o-nitro-benzaldehyde for benzaldehyde gave the nitro homologue of the substituted hydantoin. This crystallized in crystalline aggregates of a yellow brown color which gave a yellow powder when crushed. The derivative dissolves in concentrated sulphuric acid with production of a brilliant red color. When heated in a capillary tube it melts at 196–7°C. (cor.).

Analysis (Salicyl-Sulfonic acid method)

0.1128 gm. consumed 8.7 cc. 0.1 N acid, equivalent to

10.80% N. Theory for $C_{22}H_{11}O_3N_2S$ is 10.47% N.

5-Cinnamal-2,3-diphenyl isothiohydantoin.—This derivative was prepared exactly as that preceding, using 1.5 gms. (theory 1.48 gms.) of cinnamic aldehyde and 3 gms. of thiazolidone. The compound separated from the boiling reaction mixture. It was filtered off from the hot solution, washed with hot glacial acetic acid and dried. The yield was quantitative. This condensation product separates in brilliant yellow needles, which are slightly soluble in hot glacial acetic acid and almost insoluble in other organic solvents. It melts at 225–6°C. (cor.) to a clear red oil.

Analysis (Kjeldahl-Gunning-Arnold method)

0.1264 gm. consumed 6.4 cc. 0.1 N acid, equivalent to

7.09% N. Theory for $C_{24}H_{11}ON_2S$ is 7.33% N.

5-Furfural-2,3-diphenyl isothiohydantoin.—Three grams of the cyclic ketone, 1.1 (1.07 theory) gm. of furfural, 5 gms. of fused acetate and 25 cc. of glacial acetic acid were heated at the boiling point under reflux condenser for 2 hours. To the cold solution an excess of water was added when the furfurilidene derivative separated in brown needles. These were filtered by suction, washed repeatedly with water and recrystallized from acetic acid. Heated in a capillary tube they melted at 221–2°C. (cor.) to a black tar-like mass.

¹⁴ MARKLEY and HANN. JOURN. ASSOC. OFF. AGRIC. CHEM. 8: 455. 1925.

Analysis (Boric acid method)

0 2050 gm. consumed 16.65 cc. $\frac{N}{14.01}$ acid, equivalent to

8.12% N. Theory for $C_{20}H_{14}O_2N_2S$ is 8.09% N.

5-Salicylal-2,3-diphenylisothiohydantoin.—Three grams of thiohydantoin and an excess of salicylic aldehyde (theory 1.36 gms.) were heated with 5 gms. of fused sodium acetate and 25 cc. of glacial acetic acid. After 20 minutes an orange crystalline compound separated out, but the heating was prolonged for two hours to insure complete reaction. After cooling the mass was treated with water, filtered, dried and recrystallized from acetic acid. It separates in yellow acicular needles which dissolve in concentrated H_2SO_4 to give a deep red color. Heated in a capillary tube it melts at 249–50°C. (cor.) to a clear red oil.

Analysis (Boric acid method)

0 2006 gms. consumed 15.1 cc. $\frac{N}{14.01}$ acid, equivalent to

7.53% N. Theory for $C_{22}H_{16}O_2N_2S$ is 7.53% N.

5-(3,5-Dichloro-salicylal)-2,3-diphenyl isothiohydantoin.—This compound results as a product of the condensation of 2.5 (2.13 theory) gms. of chlorinated aldehyde and 3 gms. of the cyclic thiazolidone. After purification by several recrystallizations from acetic acid it separated in yellow needles which melted at 234–5°C. (cor.).

Analysis (Boric acid method)

0 2006 gms. consumed 12.6 cc. $\frac{N}{14.01}$ acid, equivalent to

6.28% N. Theory for $C_{22}H_{14}O_2N_2Cl_2S$ is 6.35% N.

5-(3,4-Dihydroxy-benzal)-2,3-diphenyl isothiohydantoin.—When a solution of protocatechuic aldehyde (1.72 gms.) and diphenyl isothiohydantoin (3 gms.) were heated in 25 cc. of glacial acetic acid, this product precipitated after one hour. It was filtered off by suction, washed with hot acetic acid and upon drying was obtained as a brilliant microcrystalline powder of light brown color. It does not melt below 300°C.

Analysis (Kjeldahl-Gunning-Arnold method)

0.1458 gms. consumed 7.0 cc. 0.1 N acid, equivalent to

6.73% N. Theory for $C_{21}H_{17}O_2N_2S$ is 7.22% N.

5-(3-Methoxy-4-hydroxy-benzal)-2,3-diphenyl isothiohydantoin.—If an excess of vanillin be heated in the presence of a dehydrating agent with diphenyl isothiohydantoin, the elements of water are eliminated and the vanillal compound is obtained. This crystallizes in yellow shining leaflets which melt at 250–1°C. (cor.) to a clear yellow oil.

Analysis (Kjeldahl-Gunning-Arnold method)

0.1205 gms. consumed 5.7 cc. 0.1 N acid, equivalent to

6.63% N. Theory for $C_{23}H_{19}O_4N_2S$ is 6.97% N.

5-(5-Chloro-vanillal)-2,3-diphenyl isothiohydantoin.—Chloro-vanillin (2.1 gms.) and diphenyl isothiohydantoin (3 gms.) were heated in the presence of acetic acid and sodium acetate for a period of 8 hours. After standing overnight the solid which separated was filtered off and recrystallized from acetic acid. It separates in fluffy crystalline masses of yellow needles which melt with decomposition at 132–4°C. (cor.).

Analysis (Kjeldahl-Gunning-Arnold method)

0.1115 gms. consumed 4.8 cc. 0.1 N acid, equivalent to

6.03% N. Theory for $C_{23}H_{17}O_4N_2SCl$ is 6.41% N.

5-(5-Nitro-vanillal)-2,3-diphenyl isothiohydantoin.—This compound was precipitated as a yellow microcrystalline powder by addition of water to a heated reaction mixture containing its constituents in molecular proportion. It melts slowly and with decomposition at 100–2°C.

Analysis (Salicyl-sulphonic acid method)

0.1155 gms. consumed 7.5 cc. 0.1 N acid, equivalent to

9.10% N. Theory for $C_{23}H_{15}O_4N_2S$ is 9.40% N.

5-(5-Bromo-vanillal)-2,3-diphenyl isothiohydantoin.—The brominated 3-methoxy-4-hydroxy benzal condensation product was prepared by the general method, given above. It separates from acetic acid as a yellow brown powder which fails to melt sharply, some decomposition beginning at 100°C. and incipient formation of a black tar results as the temperature is raised.

Analysis (Kjeldahl-Gunning-Arnold method)

0.1186 gms. consumed 5.0 cc. 0.1 N acid, equivalent to

5.91% N. Theory for $C_{23}H_{15}O_4NSBr$ is 5.82% N.

SUMMARY

Diphenyl isothiohydantoin has been condensed with benzaldehyde, o-nitro-benzaldehyde, cinnamic aldehyde, furfural, salicylic aldehyde, 3,5 dichloro salicylic aldehyde, protocatechuic aldehyde, vanillin, chloro-vanillin, nitro-vanillin and bromo-vanillin, and the condensation products analyzed and described.

GEOLOGY.—*Note on the occurrence of the Choptank formation in the Nomini Cliffs, Va.*¹ WENDELL C. MANSFIELD, U. S. Geological Survey. (Communicated by L. W. STEPHENSON.)

The Choptank formation, the middle formation of the Chesapeake group of the Maryland Miocene, was recognized in the Nomini Cliffs, Westmoreland County, Va., by Shattuck² in 1904. He says: "In the Nomini Cliffs, Virginia, it [the Choptank formation] is present as a 50-foot bed between the Calvert formation below and the St. Mary's formation above."

In 1906 Clark and Miller,³ discussing the occurrence of the Choptank in Virginia, stated: "This formation is prominently exposed in southern Maryland and Virginia, outcropping in a nearly complete section in the Nomini Bluffs on the Potomac River."

In the same year Shattuck and Miller⁴ reiterated the earlier statement of Shattuck as to the occurrence of the Choptank in the Nomini Cliffs.

In 1912, however, Clark and Miller⁵ referred the entire Miocene portion of the section at Nomini Cliffs to the Calvert formation, recognizing neither the Choptank nor the St. Marys formation in that exposure. They wrote:

"The deposits hitherto described as Choptank in the Nomini Bluffs are now known, from a more exhaustive study of both the stratigraphy and paleontology, to belong to the Calvert formation. It is possible that the Choptank may be represented, as it gradually thins out, in the low country lying between the known outcrops of the Calvert and St. Mary's formations but buried beneath the cover of Pleistocene formations."

The purpose of this note is to confirm the presence of the Choptank formation in the section at Nomini Cliffs, as originally interpreted

¹ Published by permission of the Director of the U. S. Geological Survey.

² SHATTUCK, G. B., Md. Geol. Survey, Miocene Text, pp. LXXIX-LXXX, 1904.

³ CLARK, WM. B., and MILLER, B. L., Va. Geol. Survey Bull. 2: 18, 1906.

⁴ SHATTUCK, G. B., and MILLER, B. L., U. S. Geol. Survey Geol. Atlas, St. Marys folio (No. 136), Md.-Va., p. 3, col. 2, 1906.

⁵ CLARK, WM. B., and MILLER, B. L., Va. Geol. Survey Bull. 4: 140-141, 1912.

by Shattuck, and also to indicate the occurrence of the basal portion of the overlying St. Marys formation.

The Choptank formation in Maryland, according to Maryland Geological Survey Text, 1904,⁶ is subdivided into five zones, which are numbered 16 to 20, inclusive. Zones 17 and 19 are very fossiliferous, corresponding respectively to "zone e" and "zone f" of Harris,⁷ while zones 16, 18 and 20 are either without fossils or sparingly fossiliferous.

A comparison of the stratigraphic sequence, lithologic character, and faunal contents of the beds exposed in the Calvert Cliffs, Maryland, with those in the Nomini Cliffs and elsewhere in Virginia, seems to show conclusively that the Choptank formation is represented in the Nomini Cliffs. One section in the Calvert Cliffs very closely duplicates the section in one part of the Nomini Cliffs. The Maryland and Virginia sections are given below.

Section about 1½ miles below Flag Pond, Calvert Cliffs, Calvert County, Maryland

By W. C. MANSFIELD and W. P. POPENOE

	Approximate thickness Feet
Pleistocene:	
Sand and gravel.....	30-40
Miocene:	
St. Marys formation:	
Drab plastic clay (zone 22)	15
Clean fine-grained sand, 3 feet, underlain by dark gray slightly sandy semi-plastic clay, with a few fossil im- pressions (zone 21).....	18
Choptank formation:	
Bluish sandy clay, with a 1-foot layer of indurated fossilifer- ous sand at top containing the following species: <i>Pedalion maxillata</i> (Deshayes), <i>Pecten madisonius</i> Say, <i>Asaphis centenaria</i> (Conrad), <i>Metas biplicata</i> Conrad, <i>Discinisca lugubris</i> (Conrad), <i>Schizoporella doverensis</i> Ulrich and Bassler ⁸ (zone 20).....	20
Light brown very fossiliferous sand with an indurated sand- stone layer, about 2 feet thick, at the top, carrying many individuals of <i>Pecten madisonius</i> Say (zone 19).....	10-12
Bluish poorly fossiliferous sandy clay (zone 18)	8-10
Dark gray very fossiliferous sand (zone 17), exposed.....	1

The subdivisions in the preceding section are separated into zones believed to correspond approximately to those designated in the Maryland Geological Survey Miocene Text, 1904.

⁶ *Op. cit.*, pp. LXXXI-LXXXII.

⁷ HARRIS, G. D., *Amer. Journ. Sci.* 45: ser. III, pp. 21-31, 1893.

⁸ Identified by Dr. RAY S. BASSLER, of the U. S. National Museum.

Section of Nomini Cliffs, right bank of Potomac River, Va., about 1½ miles from lower end of Cliffs

By W. C. MANSFIELD

	Approximate thickness Feet
Pleistocene:	
Reddish clay, sand and gravel.....	40
Miocene:	
St. Marys formation:	
Very plastic unfossiliferous sandy clay. Upper 3 feet consists of laminated clay alternating with thin fine sand partings. (Corresponds to zone 21.).....	18
Probably Choptank formation:	
Material similar to the above but contains 2 or 3 ferruginous layers. Appears to be unfossiliferous. (Corresponds approximately to zone 20.).....	30
Choptank formation:	
Dark brown rather soft fossiliferous sand, with an indurated sandstone layer about 2 feet thick at the top containing many individuals of <i>Pecten madisonius</i> Say. The following species were obtained from the sands: <i>Arca staminea</i> Say, <i>Pecten madisonius</i> Say, <i>Pecten marylandicus</i> Wagner, <i>Astarte obruta</i> Conrad, <i>Dosinia</i> sp. (Corresponds to zone 19.).....	10
Probably Choptank formation:	
Fossiliferous greenish-gray clayey sand. One large specimen of <i>Isocardia fraterna</i> Say was found 20 feet below indurated sandstone ledge. (Believed to correspond to zone 18 and perhaps to zone 17.).....	30

In the above section no fossils were found above the indurated layer that overlies zone 19. In places, where the material has not slumped, the cliffs stand nearly vertical and are impossible to scale, and the exact thickness of the Choptank formation can not readily be determined, but it probably amounts to 50 feet or more. The recognition of the Choptank formation in the section is based chiefly on the fossils contained in the dark brown sand 30 to 40 feet above the base. The following species, as listed above, indicate the correspondence of this layer with zone 19 of the Maryland Choptank: *Arca staminea* Say⁹ is reported only from the Choptank formation; *Pecten Marylandicus* Wagner¹⁰ is reported at six localities in the Choptank formation and at only one in the Calvert formation; *Astarte obruta* Conrad¹¹ is reported only from zone 19 of the Choptank formation at Governor Run.

⁹ Md Geol. Survey, Miocene Text, p. 388, 1904.

¹⁰ *Op. cit.*, p. 377.

¹¹ *Op. cit.*, p. 354

MINERALOGY.—*A petrographic and X-ray study of the thermal dissociation of dumortierite.* N. L. BOWEN and R. W. G. WYCKOFF.
Geophysical Laboratory, Carnegie Institution of Washington.

INTRODUCTION

Dumortierite is an aluminous mineral to which the formula $4\text{Al}_2\text{O}_3 \cdot 3\text{SiO}_2$ was originally assigned but which is now known to contain boron as an essential constituent. Several studies of the boron content, especially by Whitfield, by Ford, and by Schaller, have led to somewhat inconclusive results as to whether it is a fixed quantity, but Schaller's conclusion that dumortierite is represented by the definite formula $8\text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot \text{B}_2\text{O}_3 \cdot \text{H}_2\text{O}$ appears to be in accord with most reliable analyses.¹ A recent analysis, however, gives results closer to the formula $8\text{Al}_2\text{O}_3 \cdot 7\text{SiO}_2 \cdot \text{B}_2\text{O}_3 \cdot \text{H}_2\text{O}$ so that the question of variability in composition must be left more or less open.² Nevertheless, no reliable determinations indicate any important departure from the formula suggested by Schaller. There is present ordinarily a moderate amount of iron and titanium whose oxides presumably replace alumina and impart the commonly observed colors.

On account of its high Al_2O_3 content dumortierite has been considered as a possible basis of refractory wares. Its behavior at high temperatures is of some interest in the light of the revised Al_2O_3 - SiO_2 diagram which shows that the stable compound of these oxides at high temperatures is mullite, $3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$. A paper setting forth the results of an examination of the mineral is therefore an appropriate addition to the series of papers from this Laboratory on alumina-silica and aluminum silicate minerals.³

In the present study attention was directed principally to the dumortierite from Clip, Arizona, because its chemical composition is known and the actual analyzed sample, U. S. National Museum No. 48,200, was available for study. The analysis of this material as given by Whitfield is stated in Table 1 under A⁴ and with it, under B, a later analysis by Ford of dumortierite from the same locality.⁵ The agreement is seen to be reasonably good. Titanium is undoubtedly present

¹ W. T. SCHALLER. *Amer. Journ. Sci.* (4) 19: 211. 1905.

² T. L. WALKER. *University of Toronto Studies, Geol. Series No. 14*, p. 80. 1922

³ BOWEN and GREIG. *Journ. Amer. Ceram. Soc.* 7: 239-254. 1924.

BOWEN, GREIG and ZIES. *This JOURNAL* 14: 183-191. 1924.

GREIG *Journ. Amer. Ceram. Soc.* 8: 465-494. 1925, and *Amer. Journ. Sci.* 11: 1 26 1926.

⁴ *Amer. Journ. Sci.* 37: 218 1890

⁵ *Amer. Journ. Sci.* 14: 428. 1902.

in this mineral in considerable quantity but no determination of the amount has been made.

In addition to the more detailed thermal examination made of this Arizona material occasional comparative tests of other dumortierites were made as noted below.

THERMAL STUDY

The Clip mineral is of a deep blue color. This color disappears in a few seconds if the mineral is heated at about 800°C., at least in an oxidizing atmosphere, and the mineral becomes pure white. After 4½ hours at 800°C. the powdered mineral shows no trace of sintering. Under the microscope there is a suggestion of turbidity indicating that some decomposition may have begun, but there is no change of refractive indices or definite measurable change of any kind.

TABLE 1.—COMPOSITION OF DUMORTIERITE FROM CLIP, ARIZONA

	A	B
SiO ₂	27.99	29.86
Al ₂ O ₃	64.49	63.56
Fe ₂ O ₃		0.23
B ₂ O ₃	4.95	5.20
H ₂ O	1.72	1.41

After four hours at 950° the fine powder again shows no sintering. A definite change is now to be made out under the microscope. Irregular dark streaks have developed with elongation transverse to the prism, giving a fibrous appearance, but each grain as a whole is still of uniform extinction and negative elongation similar to the original grain of dumortierite. The refractive indices are, however, definitely lowered, γ now being 1.68, whereas it was originally 1.69.

When held at 1200° for only 10 minutes the dumortierite is almost completely changed to a material of very much lower refractive index than dumortierite. Each grain still contains, however, rare rests of unchanged dumortierite of random distribution but of uniform orientation. After 30 minutes at this temperature the mineral is completely transformed into the same substance of low refraction. This is made up of fanlike groups of radiating, fibrous structure, the fibers having fairly strong double refraction and positive elongation. It has all the appearance, even under the highest powers of the microscope, of a crystalline aggregate made up of a single substance with a mean refractive index of 1.61. When heated for longer periods the only

further change is the increasing development of irregular dark streaks that are probably cracks or voids which do not extend to the exterior of the grain and therefore do not become filled with the immersion liquid. The fibrous aggregate itself does not change appreciably in properties and is still of mean index 1.61 after heating for some days at 1200°, although the mineral continually loses weight during this period.*

X-ray examination (powder method) of the decomposition product of dumortierite as obtained at 1200° shows all the characteristic lines of mullite strongly developed and mullite is unquestionably the principal constituent.

Greig has shown that the mixture of mullite and silica obtained by heating cyanite has a mean index of 1.625, a value which is satisfactorily accounted for by the relative proportions of silica and mullite in the aggregate.⁷ The very low index (1.61) of the material obtained by heating dumortierite at 1200° can not be similarly explained, for after long heating, when most of the B_2O_3 is expelled, the material should contain only a very small amount of silica in addition to the mullite revealed by the X-rays as the dominant constituent. The mean index should therefore be only slightly lower than that of mullite. It would appear to be necessary to imagine the presence of submicroscopic voids in order to account for the low index.

Results of an intermediate character are obtained at temperatures between 950°C. where the first suggestion of a change is observed, and 1200°C., where complete transformation to material of low index (1.61) is readily effected. At 1100° the product is not significantly different from that obtained at 950°. At 1150° after 4 hours a small proportion of the dumortierite is transformed into the material of low refringence, and at 1180° after 4 hours a large proportion has suffered a like change. The X-ray diffraction patterns of these intermediate products show increasing development of the mullite lines and decreasing effects from dumortierite (Fig. 3).

After two hours at 1400°C. there is again no appreciable sintering of the powder. Under the microscope each grain is now seen to be completely decomposed and to show with moderate magnification as a nearly opaque, turbid aggregate. With high powers, two substances are definitely to be made out and, while the material is too fine-grained to permit accurate determinations, the one appears to have

* See loss of B_2O_3 on heating as given on a later page.

⁷ J. W. GREIG Amer. Journ. Sci. 11: 5-6. 1926

the refractive indices of mullite, $3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$; the other, which occurs in very small amount, is of very low index and must consist essentially of silica and boric oxide. There is no definite relation between the elongation of the fibers of mullite and the crystallographic directions of the original dumortierite, nor is there more than a moderate tendency for the mullite fibers to grow normal to the surfaces of the original dumortierite grains. In these respects the decomposition of dumortierite differs from that of andalusite on the one hand and cyanite on the other.⁸ The actual arrangement of the mullite fibers in the aggregates formed from dumortierite seems to be entirely random. Each grain of dumortierite gives a number of interfering fan-shaped aggregates of mullite fibers. Continuation of the heating for 6 hours at this same temperature (1400°) does not afford any appreciable further growth of the mullite fibers. It is to be noted that both products of decomposition are less dense than the original dumortierite, so that the change must involve some increase of volume.

After 4.5 hours at 1500° the powder is very weakly sintered into a mass which readily breaks down again into a powder between the fingers. The microscope shows the same type of decomposition as that obtained at 1400° . The mullite fibers are not significantly coarser. One observes under the microscope merely that the main bulk of the substance is a birefracting aggregate which matches a liquid of the mean index of mullite and that in it are embedded minute dots of a substance of very much lower index which can be only silica.⁹ By way of confirmation of the microscopic determination of the principal substance as mullite an X-ray photograph of the powder has been made and it shows all the characteristic lines of mullite well developed. No lines indicating any form of silica were noted, but since the silica is present in such very small amount this fact is not surprising. The lines of mullite are not distinguishable from those of sillimanite with certainty, but sillimanite is definitely ruled out in the present case because the excess material would then be corundum, and the very low index of the excess material proves that it is not. The formation of mullite and silica is in fact in complete accord with all our past observations on the behavior of synthetic mixtures or natural minerals more siliceous than $3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$.¹⁰

⁸ J. W. GREIG. Amer. Journ. Sci 11: 3-12. 1926.

⁹ As shown on a later page, B_2O_3 is now completely expelled

¹⁰ VERNADESKY heated dumortierite from this same locality to a "dazzling white heat" and concluded that the product was sillimanite. (Bull. Soc. Min. Fr. 13: 258. 1890) The above observations show that the product was necessarily mullite with a very little silica.

After $\frac{1}{2}$ hour at 1550° there is decided sintering to a firm cake and the color is now no longer a pure white, as it is after heating at lower temperatures, but is a pale grayish buff. Under the microscope it is found that definite prisms of mullite have developed, with an interstitial material of low index which is undoubtedly glass. Definite formation of some liquid is indicated by both the macroscopic and microscopic characters, the structure of this mass being altogether different from that of the individual grains as decomposed in the solid state at lower temperatures.

The behavior of dumortierite on heating is thus seen to be for all practical purposes that of material containing only alumina and silica.

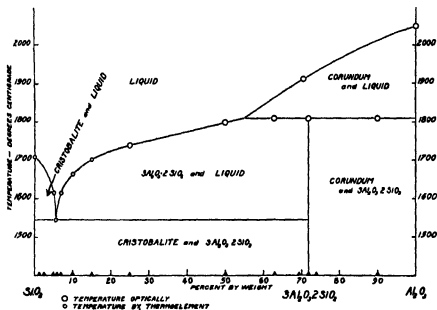


Fig. 1.—Equilibrium diagram of the system: Al_2O_3 - SiO_2 after Bowen and Greig

The equilibrium diagram of these oxides, Fig. 1, shows that beginning of melting occurs at 1545° in all mixtures lying between $3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$ and SiO_2 and in dumortierite no melting is observed until that temperature is reached. The B_2O_3 is either lost at these temperatures or the retained portion of it exerts a negligible influence.

LOSS OF B_2O_3 ON HEATING

In order to determine the readiness with which boric oxide (and water) can be driven off from dumortierite on heating, weighed samples were heated at various temperatures and the loss of weight determined.

It is to be borne in mind that the losses here given are those sustained by pure dumortierite and nothing is implied regarding the rate of loss from impure mixtures containing bases that may form more stable compounds with B_2O_3 . As might be expected, the rate of loss increases with increasing temperature, the actual results obtained being given in Table 2.

TABLE 2—LOSS OF WEIGHT OF DUMORTIERITE ON HEATING

NUMBER	TEMPERATURE	TIME	LOSS OF WEIGHT
	°C.	hrs	per cent
1	950	4	1.76
2	1200	1	2.18
3	1200	19	3.48
4	1200	46	4.10
5	1200	86	5.02
7	1400	1	2.95
8	1500	2.5	5.9
9	1500	4.5	6.6

Note: The product of No. 5 was returned to the furnace at 1250° and found to suffer an additional loss of 1.42 per cent in 44 hrs. Thus in 130 hrs. of heating, 86 of which were carried out at 1200° and 44 at 1250°, the total loss was 6.44 per cent.

The dumortierite contains about 6.7 per cent $H_2O + B_2O_3$ (see analyses of Table 1) and by reference to Table 2 it will be seen that these are quantitatively expelled at 1500°C. in 4.5 hours, whereas at 1200°C. it requires more than 130 hours to accomplish this result. At temperatures above 1500°C. B_2O_3 is, no doubt, given off still more rapidly. It is not surprising, therefore, that dumortierite should behave at high temperatures as an alumina-silica mixture. One might expect some melting at temperatures below 1545°, the eutectic between silica and mullite, on account of the retention of some B_2O_3 for a considerable period at those temperatures, but apparently its effect is negligible, for no evidence of melting is observed until after a temperature of 1545° is passed.

X-RAY OBSERVATIONS

Powder diffraction photographs have been prepared and analyzed from Arizona dumortierite and from samples of this mineral heated at various temperatures.

Accurate spacing measurements upon its principal powder lines were obtained from a series of comparison photographs from samples of dumortierite mixed with NaCl to serve as a standard. The spacings

thus determined were employed in standardizing a series of films of dumortierite alone. From these last photographs the spacings of additional lines could be found. Results of these calculations are contained in Table 3. The pattern of dumortierite contains many faint lines. On account of this multiplicity of lines many of them are not clearly resolved in the present photographs and several of the

TABLE 3.—POWDER PHOTOGRAPHIC DATA ON DUMORTIERITE

SPACING	INTENSITY
5.996Å	m
5.116	f
4.300	f
3.88	ff
3.483	m
3.258	f
2.92	m
2.69	ff
2.17	f
2.089	m
2.01	ff
1.925	ff
1.656	f
1.617	ff
1.546	f
1.480	m (d)
1.330	m
1.291	f
1.175	f (d)
1.063	ff
1.040	ff
0.973	f
0.934	ff
0.914	ff
0.877	f
0.846	ff
0.820	f

Note: Lines marked (d) in this table are diffuse. Probably they are unresolved pairs of reflections. In this and in Table 4 s, m, f and ff stand for strong, medium, faint and very faint

spacings of Table 3 undoubtedly refer to such composite reflections. This table, furthermore, is not complete because in several instances clearly visible groups of partially resolved reflections give effects so diffuse that no precise significance can be attached to measurements upon them. For the present essentially analytical uses of these patterns, however, such incomplete data are entirely adequate.

Writing the formula of dumortierite as $8\text{Al}_2\text{O}_3 \cdot \text{B}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot \text{H}_2\text{O}$,

this mineral might conceivably be considered as a hydrated mullite, $3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$, in which some of the alumina is replaced by boric oxide. In view of this possibility it is of interest to contrast the powder patterns of these two compounds. Tracings of their photographs are shown in Figure 2. They clearly have no obvious relation to one another.

Powder photographs have also been studied from samples of dumortierite heated for 4 hours at various temperatures. Spacing measurements upon them are stated in Table 4, their tracings are to be found in Figure 3. The principal lines of these photographs are seen to be essentially identical with the principal lines in the patterns of either

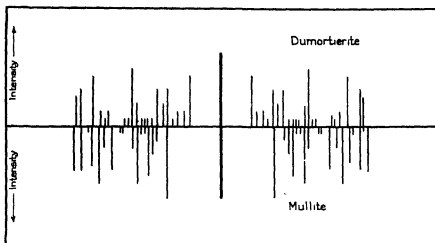


Fig. 2.—Tracings of the positions of the principal powder lines of dumortierite and of mullite. The lengths of the lines in this diagram are roughly proportional to the relative intensities of the corresponding reflections.

dumortierite or mullite. The measurements upon these photographs are not absolute determinations of spacings but were obtained by taking three or four conspicuous lines on each film as standard and establishing the relation of other lines to them. Such a simple procedure is sufficient for the present purposes.

Since dumortierite loses boric oxide and water at temperatures far below those at which the mullite pattern is observed it might be expected either that the dumortierite pattern itself would change as a result of these heatings, or that an amorphous material would appear as an intermediate stage in the decomposition of dumortierite. Small differences in relative intensities between the patterns of natural dumortierite and of this mineral after heating to 1100° and 1150°

appear to exist but the data of Table 4 show no well-defined alterations in the observed spacings. These diffraction observations thus prove that the structure of dumortierite remains essentially unchanged after heating for 4 hours at 950° and 1100°C. and that mullite is the chief product arising from heating dumortierite to 1200° or 1500°C.

TABLE 4.—SPACING DATA ON DUMORTIERITE DECOMPOSED AT VARIOUS TEMPERATURES

ORIGIN OF LINE	SPACINGS AND APPROXIMATE INTENSITIES						
		950°	1100°	1150°	1190°	1200°	1500°
D	m	5.91 Å		5.82 Å	—	—	—
D	f	5.11		5.00	—	—	—
D	f	4.33		4.42	—	—	—
D	f	3.88		3.90	—	—	—
D	m	3.48	3.49 Å	3.47	—	—	—
M		—	—	—	(3.411) Å	(3.411) Å	(3.411) Å
D	f	3.25	3.25	—	—	—	s
D	m	(2.918)	(2.918)	(2.918)	2.93	—	—
M		—	—	—	—	2.88	2.88
D, M	ff	—	2.68	2.70	2.70	2.70	2.72
M		—	—	—	2.53	2.53	2.54
M		—	—	—	—	2.29	2.28
D	m	2.20	2.21	2.21	(2.197)	(2.197)	(2.197)
M							
M		—	—	—	—	2.11	2.12
D	s	(2.089)	(2.089)	(2.089)	2.08	—	—
D	f	1.93	1.93	1.92	1.93	—	—
M		—	—	—	—	1.88	ff
M		—	—	—	1.82	1.83	ff
M		—	—	—	1.70	1.70	1.70
D	ff	—	1.67	—	—	—	—
D	ff	—	1.62	—	—	—	—
M		—	—	—	1.60	1.59	1.59
D	f	1.55	1.54	1.54	—	—	—
M		—	—	—	(1.518)	(1.518)	(1.518)
D	s	(1.460)	(1.460)	(1.460)	1.46	—	—
M		—	—	—	1.42	1.43	1.43
D, M	m	1.34	1.34	1.34	1.34	1.33	1.33
D	f	1.29	1.29	1.30	—	—	—
M		—	—	—	1.26	(1.260)	(1.260)

Note: In the first column of this table D and M refer to dumortierite and to mullite respectively. The patterns of dumortierite decomposed at 1200° and at 1500° are practically those of mullite,¹¹ the spacings of the principal lines of dumortierite are given in Table 3. Absences of reflections are indicated by bars; vacancies (as for instance for the long spacing lines in the 1100° column) do not mean the absence of these lines. Standard lines are enclosed in parentheses.

¹¹ J. T. NORTON. Journ. Amer. Cer. Soc. 8: 401 (1925); L. NAVIAS and W. P. DAVESY, Journ. Amer. Cer. Soc. 8: 640 (1925); R. W. G. WYCKOFF, J. W. GREIG and N. L. BOWEN, Amer. Journ. Sci. (in press).

The pattern of this mineral heated at 1150° is to be interpreted as that of dumortierite with a small amount of admixed mullite; the photograph arising from the 1150–80° heating shows mainly mullite with some undecomposed dumortierite. The patterns of these high temperature products are somewhat weaker than those of unchanged

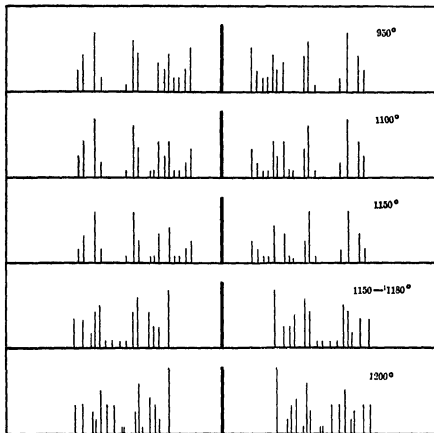


Fig. 3.—Tracings showing the positions and the approximate relative intensities of the principal lines observed in the powder photographs of dumortierite heated at various temperatures.

dumortierite, but they do not show the intense blackening which should be found if any considerable portion of the sample had become amorphous.

DUMORTIERITE AS A REFRACTORY

Dumortierite is to be regarded favorably as a basis for refractory bodies, and, on account of its higher Al_2O_3 content, as having some

advantages over the silicates of composition $\text{Al}_2\text{O}_3 \cdot \text{SiO}_2$, namely, sillimanite, andalusite, and cyanite. Indeed, dumortierite may, for refractory purposes, be looked upon as having the formula which was, by mistake, originally assigned to it, namely, $4\text{Al}_2\text{O}_3 \cdot 3\text{SiO}_2$, and its thermal behavior may be read off from the alumina-silica diagram. Though some liquid is formed at 1545° the amount (4 per cent) is considerably less than that formed with sillimanite, andalusite, or cyanite (14 per cent) so that failure under load at that temperature should be much less notable. With further rise of temperature increase in the amount of liquid is very slow until about 1700° , where it amounts for the 4:3 mixture to about 6 per cent. The liquid then increases more rapidly until at 1810° it amounts to about 18 per cent. The 4:3 mixture has therefore only a slightly greater amount of liquid at 1810° than the 1:1 mixture has at 1545° , though, in the latter case, the liquid is much more viscous. At 1810° the 4:3 mixture is abruptly transformed from mullite with a little liquid (18 per cent) to corundum with much liquid (nearly 70 per cent) and all its refractory power must there disappear.

In so far as dumortierite approaches the theoretical composition represented by the formula $8\text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot \text{B}_2\text{O}_3 \cdot \text{H}_2\text{O}$ its behavior at high temperatures should approach that outlined above. If it is really somewhat variable in composition, and especially if the ratio of alumina to silica may in some examples be not so great then these examples will not be quite so refractory.

OBSERVATIONS ON DUMORTIERITE FROM NEVADA

In addition to the very pure dumortierite from Arizona, dumortierite from the Rochester Mining District, Nevada, was examined.¹⁴ None of this dumortierite is free from foreign matter which is almost exclusively muscovite. Two classes of material were treated, the one a select specimen with 3 or 4 per cent muscovite, the other, with about 20 per cent muscovite, which appears to represent the general run of material there available. At lower temperatures decomposition of the dumortierite into mullite and silica takes place in exactly the same way as in the Arizona mineral. Even at high temperatures the specimen with only a little mica did not show any significant departure in behavior from the purer Arizona mineral. In the specimen with the greater amount of mica, however, definite sintering begins at a lower

¹⁴ This material was kindly supplied by ERNEST E. FAIRBANKS, Bureau of Mines Reno, Nevada.

temperature. The formation of some liquid is in fact apparent at 1500° , and at 1550° the amount of liquid is definitely greater than that in the specimen with only a little mica. Both give a pure white product even when definite partial melting has occurred. In this respect the pale-colored dumortierite from Nevada differs from the deep-blue Arizona mineral which, as we have seen, gives a slightly colored product when carried to temperatures where some formation of liquid occurs. No observations on the loss of weight were made on the Nevada dumortierite.

SUMMARY

The dissociation of dumortierite, $8\text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot \text{B}_2\text{O}_3 \cdot \text{H}_2\text{O}$, at high temperatures has been studied and it is found that decomposition of the crystals occurs with formation of mullite, $3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$, and a little excess material. The first definite evidence of a change is obtained at 950° , but the products of decomposition are recognizable by their microscopic and X-ray characters only at higher temperatures.

X-ray diffraction photographs (powder method) have been made of dumortierite and of its decomposition products as obtained at various temperatures. The results of measurements of the lines of these photographs are given in Tables 3 and 4 and Figures 2 and 3.

Formation of a little liquid with definite sintering occurs first at 1550° . Determination of the loss on ignition shows that B_2O_3 and H_2O are completely expelled at 1500° in 4.5 hours and almost completely in a much shorter time. At such temperatures, then, the product of decomposition is mullite with a little free silica, and the fact that liquid first appears at 1550° is due to melting at the eutectic between mullite and SiO_2 (1545°). The mineral thus behaves for all practical purposes as a simple mixture of alumina and silica, nearly, if not actually, in the proportion $4\text{Al}_2\text{O}_3 \cdot 3\text{SiO}_2$, and its thermal behavior can be read off directly from the alumina-silica diagram, Fig. 1.

ENTOMOLOGY.—*The occurrence of Phlebotomus in Panama.*¹

RAYMOND C. SHANNON, Bureau of Entomology. (Communicated by S. A. ROHWER.)

The members of the genus *Phlebotomus* form one of the best known groups (*Psychodidae*) of bloodsucking Diptera. Particularly is this true in certain southern European, Asiatic, and African countries where, owing to the fact that certain species are carriers of disease and others are suspected to be, a rather thorough investigation has been made of their habits, distribution, and classification.

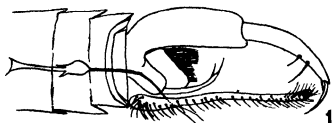
The American species have yet to undergo such an intensive investigation, for only twelve have been described, and these mostly from South America. Several species have been suspected of carrying disease, there being considerable evidence to show that *P. verrucarum* Townsend is the vector of verruga fever in Peru, while both *P. brumpti* and *P. intermedius* are suspected of being transmitters of American leishmaniasis.

There are as yet no published records of the occurrence of *Phlebotomus* in Panama. However, in 1911, Mr. August Busck collected two females at Cabima, Panama. These were tentatively determined by Knab as "*P. squamiventris* L. & N." and "*U. rostrans* Summers," respectively.

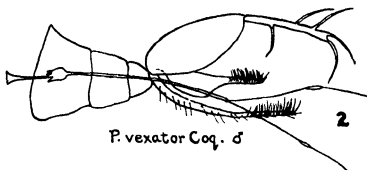
In 1923, the writer collected a number of specimens, at three localities in Panama. The first were taken in the month of May in the daytime by means of sweeping with a net at the bases of large coipu trees growing in the midst of an uncut forest area located near Cano Saddle, on one of the back arms of Gatun Lake. A number of females and one male were secured in this manner. In June and July, while the writer was investigating the mosquito fauna of Barro Colorado Island, in Gatun Lake, at that time a wholly uninhabited and nearly virgin forest area, he again encountered *Phlebotomus*. The midges were attracted by the camp light (a gasoline lantern) and rested upon objects well within the range of the light. They bit rather frequently, the bite being distinctly sharper than an ordinary mosquito bite. Towards morning they would leave the light and hide themselves

¹ An excellent summary of our knowledge of the species of *Phlebotomus* has been published by F. LARROUSSE, *Etude Systematique et Médicale des Phlébotomes*, 1921, pp. 1-106

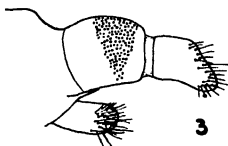
Fig. 1—Male terminalia of *Phlebotomus panamensis* Snn. Fig. 2—Male terminalia of *P. vezator* Coq. Fig. 3—Female terminalia of *P. panamensis* Snn. Fig. 4.—Female terminalia of *P. vezator* Coq. Fig. 5.—Female terminalia of *P. cruciatus* Coq.



Phlebotomus panamensis Smn. ♂



P. vexator Coq. ♂



P. panamensis Smn. ♀



P. vexator Coq. ♀



P. cruciatus Coq. ♀

Figs. 1, 2, 3, 4, and 5; see page 190 for description

away for the day. Only females were taken. At Porto Bello, Panama, the writer collected a single female in a cave-like dungeon in one of the old Spanish forts in the city. The dungeons were inhabited both by bats and snakes; either, or both probably, serve as hosts for the midges.

It would seem from the above observations that man is not a normal host for these bloodsucking midges; and, in the writer's experience, no ill effects were felt from their bite.

All of the collections of *Phlebotomus* from Panama proved to belong to a single new species, which is here described.

***Phlebotomus panamensis*, new species**

Description of male and female.—Very similar in general appearance to other species of *Phlebotomus*. Integument pale yellow; antennae sixteen-jointed; palpi apparently four-jointed, the basal joint well fused with the second, the relative lengths of the joints (considering the two basal joints as one and the first joint) are 1: 0.90: 0.15: 0.25. All of the body pile long and erect. Subcosta ending free at about the basal third of the wing; distance between tips of R_1 and R_2 greater than distance between tips of R_2 and M_1 ; petiole of upper forked cell a little more than half the length of R_1 ; petiole of lower forked cell is to the upper branch of the cell as 3:5.

Male clasper: Four spines present, arranged in a double group; the terminal spine the longest. Other genitalic characters are shown in the figure. Apparently eight abdominal segments are present, the seventh and eighth appear to be telescoped into the sixth.

Female terminalia: The cerci, or terminal lobes, and the ventral lobes of three species before me, *P. panamensis*, *P. cruciatus*, and *P. vezator* show certain differences which may aid in distinguishing these species in this sex. (See figures 3, 4, and 5.) *P. cruciatus* has much larger terminal lobes than have the other two species, and they are more than twice as long as broad and more finely setulose; in *P. panamensis* the terminal lobes are subquadrate, except that the lower distal corner is obtusely produced; in *P. vezator* the terminal lobes are similar to those of *P. panamensis*, except that they are somewhat larger.

The key to the American species, based on male genitalia, given by Larrouse, shows that *P. longipalpis* Lutz & Neiva (Brazil) may be the nearest ally, among the known species, to *P. panamensis*. The terminal palpal joint in that species is longer than any of the preceding

joints, whereas in *P. panamensis*, the last joint is much shorter than the antepenultimate joint.

Type locality.—Cano Saddle, Canal Zone, Panama.

Type.—Cat. no. 28726, U. S. N. M.

Male type, female allotype, Cano Saddle, Canal Zone; eight female paratypes, Cano Saddle, Barro Colorado Island, Canal Zone, Porto Bello, May–August, 1923, collected by R. C. Shannon; Cabima, Panama, May 22, 1911, collected by A. Busek.

ANTHROPOLOGY.—*The subjective element in magic.* JOHN R. SWANTON, Smithsonian Institution.¹

The theory that religion originated in animism, belief in souls resident in or associated with plants, animals, natural and artificial objects, was, as is well known, propounded by E. B. Tylor more than fifty years ago; and, as is also well known, J. G. Frazer later set up an opposing theory to the effect that animistic beliefs were secondary, having sprung from an earlier stage in which men's minds were dominated by magic. Frazer's hypothesis has been repeatedly and thoroughly grilled by leading British and American anthropologists such as Lang, Marett, Goldenweiser, and Lowie, all of whom take issue with the learned author, and in general it may be said that there is no tangible proof for the evolutionary succession for which Frazer contended. However, his critics have not found it altogether easy to place magic and religion in their proper mutual relations.

Magical practices seem to be accomplished in three ways, (1) through spirit intermediaries whose coöperation can not be counted upon with certainty, (2) through spirit intermediaries who are absolutely governed by the magician—or perhaps rather by the magical incantation, or (3) without spirit intermediaries. The first of these is generally conceded to belong in very large measure in the province of religion, while the second is usually classed as magical. But since the theoretical control over spirits exercised by a worker in magic varies greatly it is difficult to draw a sharp line between practices belonging to these two classes. The conception of spirit helpers is certainly furnished by religion, and where their services are absolutely constrained we may perhaps say that we have a magic-religion complex with magic dominant.

Practices of the third type are, of course, those most typical of magic as distinguished from religion, but when we come to concrete

¹ Received February 19, 1926.

examples the anthropomorphizing urge is so great that it is difficult to be sure that they are entirely sterilized of the religious element. And, having apparently segregated¹ cases of true magic, are we sure that what we have left is anything more than the effect of a theory of causation differing in no respect from hypotheses involving purely natural phenomena? Indeed primitive man frequently applies terms generally reserved for the supernatural to purely natural occurrences. There are people with little or no superstition in their make up who believe that mind may communicate with mind directly over wide spaces. If it should turn out that they are right, the primitive magician who attempts to benefit or injure at a distance by mental action would deserve so much the more credit. Should we *then* class his efforts as magical or scientific? But that is not all. Granted that they are magical and supernormal from our point of view, are they from his? Lowie well says: "But the residue [of native lore], which *we* are obliged to reject when testing it in the light of *our* knowledge, does not, for that reason, belong to a different category from a psychological point of view. . . . In so far as [primitive man] observes and reasons without enveloping his mental operations with the atmosphere of supernaturalism he is none the less a scientist or at least a precursor of science because of his errors, for mistakes from sheer ignorance are committed by our greatest thinkers."² Not only so, but some of our greatest thinkers, Kepler for instance, hit upon cardinal scientific truths while their minds were enveloped in "the atmosphere of supernaturalism" and therefore the atmosphere of supernaturalism becomes a rather insecure determinant of the distinction between magic and science.

But whether or not any of the scientific attitude attaches to magical practices and superstitions of related character numbers of them perform subjective services, or supposed services, of another kind which go far toward explaining their existence and their persistence. I mean simply this, that the act in question keeps a desired end in view, or at least serves to exclude from the thoughts an undesired and hence unpleasant end. When, for instance, the Zulu chews a bit of wood "in order, by this symbolic act, to soften the heart of the man he wants to buy oxen from, or of the woman he wants for his wife,"³ the proceeding at least suggests and keeps before his mind the accomplishment of something agreeable. In view of the unexplored character of

¹ R. H. LOWIE, *Primitive Religion*, p. 148.

² E. B. TYLOR, *Primitive Culture*, 1: 118 (quoted from Grout, Zulu-land).

much of the mental life even a civilized man might, under similar circumstances, think that *perhaps* his rite would be of some avail, and in the grade of development to which the Zulu belongs such a suggestion would be tenfold more powerful. At least, if timidity, remoteness from the persons in question, or other causes prevented the performer from taking more effective action, such a bit of imitative magic would furnish an outlet for his unsatisfied mental strivings.

Similarly, when the wizard endeavors to injure or kill an enemy by making an image of him and mistreating it in various ways, his efforts will ordinarily be without direct avail. Still, the desired end may be accomplished by the effect of these activities on the equally superstitious mind of his victim, and in any case the act serves to feed the spirit of hatred which the magician entertains, helps him to "nurse his wrath," and thus performs a service, although a perverted one, to the doer. The same argument applies in the case of hunting charms, war medicines, mascots, etc. They suggest success, help to keep up the spirit of the owner or owners, and hence actually add to their courage and feeling of competency. Even the possession of a rabbit's foot may have an exhilarating effect on a highly educated gentleman of our own times which he would be ashamed to admit. Faced with an uncertain future of infinite possibilities, and recognizing that unknown laws are at work about him, the bewildered individual tends to grasp at anything which suggests a happy outcome and, at least, something associated in his mind with success. This may be a thing purely individual, as in the wearing of a particular scarf-pin, or a certain dress, or the carrying of a sketch as in instances cited by Tozzer;⁴ or it may be something which his group or associates have come to hold in such esteem. Cases of the latter kind are the rabbit's foot just mentioned, the mascot of the college or the athletic team, or the palladium of a tribe. When in doubt or perplexity, man tends to lean on his fellows or his group, and when the group has come to associate good or ill fortune with this, that, or the other object, it is the easiest thing in the world to resolve the perplexity by accepting the group superstition. This, of course, applies to group ideas of all kinds, whether or not of the nature of charms. "Of course," we say, "*we* are not superstitious," but we do not know how to meet the present emergency, the use of a rabbit's foot or a particular amulet is an ancient and widely spread custom, and that fact argues that "there must be something in it," and anyhow "it can do no harm."

⁴ A. M. TOZZER, *Social Origins and Social Continuities*, pp. 242-266. 1925

A personal experience may help along the thought at this point. When a boy the writer used to dress in a room heated by an airtight stove. Before brushing his hair he was in the habit of wetting the hairbrush at the washstand, and as this was on the opposite side of the room from the mirror, he was obliged to pass the stove going and coming. As he passed the stove on his way back he fell into the habit of flinging a little water off of his brush upon it in order to hear the sizzle. But, after this little custom had been kept up for some time, he one day determined he would omit the ceremony, and he was straightway conscious of a distinct sense of discomfort, while the thought flashed through his mind from nowhere in particular, "Supposing bad luck should follow the omission." Evidently the cause of the discomfort was the breaking of a partially established habit, a discomfort of the kind that compelled old Dr. Johnson to go back and strike any fence post he had omitted hitting with his cane. The thought consequent on the discomfort may have had a religious origin; it was perhaps a vague attempt to interpret in religious terms an unpleasant sensation which was purely psychological, the distaste of the organism toward any interference in a customary exercise.

In most cases such superstitions probably do "do harm," because life is too short to clutter it up with useless formulas. The mental machinery will register impressions based on sound reasoning as readily as meaningless imitations of what our neighbors do or our ancestors have done, and our time should be devoted to the former occupation.

However, there are suggestions connected directly with magic which are beneficial, even though they may be irrational. There is no question that certain sights and sounds have an alleviating effect on the sick. Some perhaps serve merely as counter irritants to remove the mind from its immediate troubles, but others are of a kind to turn the flow of the patient's thoughts strongly to a happy outcome. When a Haida woman was about to give birth, it was customary to let an eel slide down to her feet inside of her clothing, the slippery nature of the creature and the direction it took indicting easy parturition, and a similar suggestion was involved in many magical practices on this and other occasions. If a patient strongly believed that the pain in his arm was due to a witch arrow and the doctor could seem to suck this out and actually show it to him, the alleviation of the apparent symptoms was probable and their actual alleviation in certain cases more than likely.

The Chickasaw attempted to cure by a powerful use of group suggestion. The entire neighborhood would be summoned to the house of the sick person, a fire lighted east of the main doorway, which was always toward that quarter as being the good luck direction, little canes adorned with ribbons, images, and other objects properly conjured by the doctor, were stuck in the ground near the fire, and all of the guests danced about between the fire and the house while the sick man himself sat in the doorway looking on, or was supported by others in that position. The vigorous actions of the dancers were supposed to energize the patient and "dance away" his malady. In other words he was made the focus of a powerful assembly of suggestions, composed of all kinds of good luck signs, the concentrated belief of his neighbors, and their display of energy which he was taught to think was working upon his indisposition.

The elaboration of the charm, mascot, fetish, palladium, or ceremonial in order to suggest more intensely the end to which it was believed to lead would of course be thought to increase the possibility of attainment, but it would certainly make the desire more vivid and in the same measure increase the subjective satisfaction of the magician and his friends. Hence such efforts cannot be said to have been entirely unserviceable although in many cases they were socially undesirable. It is perhaps worth considering whether this motive may not have acted as a powerful stimulus in the evolution of the arts.

My conclusion is that, whatever religious element may attach to magic, it is to be explained mainly by reference to immediate psychological processes, particularly those of the magician himself.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

929TH MEETING

The 929th meeting, the first of the year 1926, was held in the Cosmos Club auditorium on Saturday evening, January 9, 1926. The meeting was called to order at 8:31 by President BOWIE with 67 persons present. The address of the evening was given by the retiring president, J. A. FLEMING, on *The magnetic and electric survey of the earth; its physical and cosmical bearings and development*. It appears in full in an early issue of the JOURNAL. (This JOURNAL, 16: 109-132, 1926.)

930TH MEETING

The 930th meeting was held in the auditorium of the Cosmos Club on Saturday evening, January 23, 1926. The meeting was called to order by President BOWIE at 8:15 with 49 persons in attendance.

Program: E. O. HULBURT: *The propagation of radio waves over the earth.*—In this paper a quantitative theory of the propagation of radio waves over the earth is presented. Larmor's theory of refraction due to the electrons of the Kennelly-Heaviside layer does not explain the "skip distances" for short radio waves (regions of silence around the transmitter which Taylor's measurements showed to be 175, 400, 700, and 1300 miles in radius in the daytime, averaged over the year, for waves of 40, 32, 21 and 16 meters, respectively, and which are surrounded by zones of strong signals). The range as a function of wave-length shows a minimum for about 200 meters which suggests the introduction of a critical frequency term. If the effect of the magnetic field of the earth on the motion of the electrons is taken into account, as suggested by Appleton and by Nichols and Schelleng, the modification of the Larmor theory necessary to fit it to the experimental facts is secured.

The upper atmosphere is assumed to contain N free electrons per cubic centimeter, and neglecting absorption the dispersion equations are worked out for various modes of polarization of the radio waves. Then the skip distances are computed, making various assumptions as to the electron density distribution. (a) Reflection theory. As a first approximation the layer is taken to be sharply separated from the un-ionized lower atmosphere. At this layer total reflection occurs in accordance with Snell's law. (b) Refraction theory. The following distributions are considered: (1) Density increasing linearly with the height h , beginning at a certain height h_0 ; (2) Density proportional to h^2 ; (3) Density proportional to e^h ; (4) Density proportional to $h^{1/2}$. Comparison with the experimental skip distances shows good agreement, and indicates that the radio waves which just reach the edge of the zone beyond are refracted around a curved path, reaching in the daytime a maximum height of from 97 miles (case 1, $h_0 = 21$ miles, and case 2) to 149 miles (case 3). At this height the electron density comes out close to 10^8 electrons per cubic centimeter. At night the electron density gradient is less and the height is greater.

These conclusions agree with physical conceptions from other evidence. From the dispersion equations it follows that for waves of 60 to 200 meters, total reflection may occur from the electron layers at all angles of incidence. From this result, combined with interference between various modes of polarization of the radio rays, a detailed qualitative explanation of many fading phenomena is presented. Further conclusions are: That the ions in the atmosphere have little effect in comparison with the electrons; that for longer waves the Larmor theory is correct; that short waves are propagated long distances by refraction in the upper atmosphere and reflection at the surface of the earth, not by earth-bound waves; that waves below 14 meters can not be efficiently used for long distance terrestrial communication, but appear to offer a possibility of interplanetary communication. (*Author's abstract.*)

J. H. SERVICE: *Recent results with radio-acoustic ranging.* (Illustrated with lantern slides.) The radio-acoustic method of position finding was taken up by the Coast and Geodetic Survey in the fall of 1923. The introduction to the paper reviews briefly the construction and operation of the original apparatus and the procedure originally followed, involving stopping the ship, firing a bomb in the water alongside and recording the time. Sound energy from the bomb travels through the water to hydrophones at two or more shore stations. The reception of sound at a given shore station, by means of amplifier and relays, causes a characteristic radio signal to be sent

out from that station, which is received aboard the ship and timed. Time of travel of sound energy and thence distance to each station is thus obtained.

The following improvements have been made during the past two years: Design of a special bomb for great distances, more efficient procedure in hydrophone and cable installation and recovery, the obtaining of fixes without reduction of the speed of the survey ship, elimination of stray hydrophone disturbances, automatic shore station operation and improved methods of plotting.

The method has been shown to be practical for distances between ship and shore station up to 200 miles (unless unfavorable bottom conditions intervene), and gives a location for the ship with a maximum distance error varying from some 75 meters to somewhat less than a mile as the distance between ship and shore stations increases from 10 miles to 200 miles. A shore station will function automatically for over a week of continuous operation without attention.

Some of the problems awaiting solution are: obtaining a more suitable hydrophone cable, the modification of the apparatus to permit the use for short distances of a sound source more convenient than explosions, the development of a sound receiver better than a microphone, and modification of the apparatus so as to make possible the detection of sound energy transmitted across unfavorable bottom conditions.

The use of the method has brought to light strong evidence to indicate that the sound energy from bomb to hydrophone is transmitted largely by means of multiple reflections between the surface and the bottom. (*Author's abstract.*)

H. A. MARMER, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The annual party of the Pick and Hammer Club was held on March 6. Among the former members of the U. S. Geological Survey present were: RALPH ARNOLD, petroleum engineer of Pasadena, California; EDWARD SAMFSON of Princeton University; and K. C. HEALD.

Mrs. NORA DOWELL STEARNS resigned from the Water Resources Branch of the U. S. Geological Survey on March 1.

The following members of the U. S. Geological Survey expect to attend the International Geological Congress in Madrid, Spain, May 24-31: H. G. FERGUSON, M. I. GOLDMAN, G. M. HALL, D. F. HEWETT, and E. O. ULRICH. Mrs. Ferguson, Mrs. Goldman, and Mrs. Hewett will also be members of the party. Most of the geologists will attend one or more of the geological excursions to regions of especial interest in Spain and northern Africa. Mr. HEWETT left Washington March 12, and will make several geologic investigations in Greece, Italy, and Sardinia before the congress. Mr. GOLDMAN leaves on April 15, Mr. FERGUSON April 24, and Mr. ULRICH May 12.

ARTHUR KEITH is on leave from the U. S. Geological Survey for the two months beginning March 17, to give a course of lectures on *Structural geology of North America* at the University of Texas, at Austin.

ROBERT T. BOOTH will be succeeded April 1, 1926, by RICHARD H. GODDARD as observer-in-charge of the Huancayo Magnetic Observatory (Peru) of the

Carnegie Institution of Washington. Mr. Booth will return to Washington across South America via the Amazon as a member of the special expedition of Messrs. DAHL and RAMBERG.

DAVID WHITE, W. C. MENDENHALL, W. T. THOM, Jr., L. W. STEPHENSON, H. D. MISER, C. H. DANE, H. W. HOOTS, N. W. BASS, and J. D. NORTHOP of the United States Geological Survey attended the annual meeting of the Petroleum Geologists at Dallas, Texas, on March 25, 26, and 27.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 16

APRIL 19, 1926

No. 8

PHYSICS.—*Diffraction by a grating.*¹ G. BREIT. Department Terrestrial Magnetism, Carnegie Institution of Washington.

It is known that Fraunhofer interference phenomena may be explained by means of Duane's hypothesis² of the transfer of momenta in quanta. According to this explanation, only momenta of amount $\frac{nh}{a}$ may be transferred laterally to a plane grating if a is the grating space. For low intensities of incident radiation the amount of light diffracted into a given order is proportional to the intensity of the incident light. This suggests that the action of a grating is similar to that which would exist if we had simple collisions between light quanta and the grating. However, a consideration of black body equilibrium shows that this is not the case and that the grating is similar in its action to an atom. It seems almost obvious that the actions of a resonator and of a grating are very similar because a conducting rod of a given length forms a transition step between the two.

It is known that the relative intensities of various orders in the diffraction pattern of a grating may be varied within wide limits. This shows that for theoretical purposes we may require that a grating reflecting only within one order should be in proper equilibrium with black body radiation. We postulate that the mean kinetic energy of each degree of freedom of the translational motion should be $\frac{kT}{2}$, where k is Boltzmann's constant and T the absolute temperature. Whenever a quantum is diffracted by the grating, it acquires a

¹ Received March 9, 1926.

² DUANE. Proc. Nat. Acad. Sci., May, 1923

COMPTON. Proc. Nat. Acad. Sci., 9: 359.

EPSTEIN and EHRENFEST. Proc. Nat. Acad. Sci., 10: 133

BREIT, G. Proc. Nat. Acad. Sci., 9: 238-246, 1923.

momentum laterally of amount $\frac{n\hbar}{a} = \frac{\hbar}{b}$ where $b = \frac{a}{n}$. We further simplify the consideration by supposing that the material of the grating is selectively reflecting at a frequency ν . [This may be shown to be equivalent to assuming that its reflection curve is arbitrary.]

We have then that Einstein's² coefficient $\frac{\Delta^2}{\tau}$ is proportional to $\frac{\hbar^2}{b^2} \rho(\nu)$, where $\rho(\nu)d\nu$ is the energy density in the frequency range $d\nu$.

Einstein⁴ showed that if black body radiation is referred to a frame of reference moving with velocity v , then in a direction making an angle φ with the direction of motion the energy density is to within the first order of v

$$\rho(\nu) + \frac{v}{c} \cos \varphi \left(\nu \frac{\partial \rho}{\partial \nu} - 3 \rho(\nu) \right)$$

If we suppose now that the diffraction in various directions is determined entirely by the number of hitting quanta and if each element of the grating is capable only of ordinary reflection, Einstein's coefficient R is proportional to $\nu \frac{\partial \rho}{\partial \nu} - 3 \rho(\nu)$. Hence in order that the equation

$$\frac{\Delta^2}{\tau} = 2RkT$$

(Einstein *loc. cit.* 125, form 12) be satisfied we must have

$$\frac{1}{\rho} \left(\nu \frac{\partial \rho}{\partial \nu} - 3\rho \right) = \text{const.} = \nu \frac{\partial(\log \rho)}{\partial \nu} - 3 \quad (1)$$

With Planck's form of the radiation law this is clearly impossible (though the Rayleigh Jeans approximation satisfies the above requirement). Hence here just as in the case of atoms (Einstein *loc. cit.*) and free electrons³ the influence of the presence of radiation on diffraction probabilities must be taken into account. The above-mentioned papers and the paper by Einstein and Ehrenfest⁵ indicate how this is to be done. According to the generalization of Einstein and Ehrenfest, Pauli's result may be interpreted to give the probability of scattering as the product of two independent probabilities: (a) The probability of absorption, (b) the probability of re-emission.

² Einstein. *Zeits. Physik* 18: 121, 1917.

³ *Loc. cit.*

⁴ PAULI. *Zeits. Physik* 18: 272, 1923.

⁵ EINSTEIN and EHRENFEST. *Zeits. Physik* 19: 301, 1923

For the case of a heavy grating we may simply suppose then that the resultant probability of scattering is such as though the grating were capable of absorbing and emitting as an atom does.

Similar indications are given by the Doppler effect. Schroedinger showed that the Doppler effect may be understood in quantum theory by considering an absorbing and an emitting atom and by bringing into the discussion the changes in the energy of the quantum due to the recoil actions of the atoms. It is clear, therefore, that if a grating is treated as a generalized atom Schroedinger's reasoning will apply and all required conditions will be satisfied. If, however, the purely mechanistic point of view be taken, a difficulty is encountered at once in considering the diffraction by a moving grating. If, for example, the grating be moving with a velocity v towards the incident light and if the incidence be normal, the angle of diffraction in the frame of the grating should be θ' given by

$$a \sin \theta' = n\lambda'$$

where λ' is the wavelength of the incident light in the frame of the grating. If the grating be stationary

$$a \sin \theta = n\lambda$$

Thus

$$\frac{\sin \theta'}{\sin \theta} = 1 - \frac{v}{c} \quad (2)$$

On the other hand, if the mechanism of diffraction were always that of imparting the same amount of momentum laterally to the grating as measured in the stationary frame, another angle θ'' would result for the diffraction. This is easily shown to be such that

$$\frac{\sin \theta''}{\sin \theta} = 1 - \frac{v}{c} \cos \theta \quad (3)$$

[To within first powers of $\frac{v}{c}$.]

The disagreement of (2) and (3) shows that the assumption underlying (3) is not valid.

It may be suggested that the grating and the photographic plate should be looked upon as a complex atom. From a purely formal point of view the absorption by such an atom can be calculated by the Correspondence Principle. Similarly for its emission. We consider the latter first. The point of Duane's idea is from this point of view that in addition to the quantum numbers of the emitting atom one

may speak also of a quantum number of the grating, and that diffraction in various directions is given by different changes in that quantum number. This quantum number according to Duane is the momentum of the grating divided by h . Appealing as this picture of Duane's seems to be, it seems necessary to apply it only for phenomena of our complex atom within itself.

BOTANY.—*New Piperaceae from South America and Mexico.* WILLIAM TRELEASE, University of Illinois. (Communicated by E. P. KILLIP.)

Among specimens of South American and Mexican Piperaceae recently submitted to me by the United States National Museum for study the following new species and varieties were found:

***Piper austro-mexicanum*, sp. nov.**

A shrub?; twigs somewhat zig-zag; flowering internodes rather thick and short (3×15 – 30 mm.), granular-scrabrous and rather persistently upcurved-hirsute; leaves elliptic-oblong, subacuminate, rounded at base with one side somewhat shorter, moderate (4 – 5×12 – 15 cm.), pinnately nerved from below about the middle, the nerves about 6×2 , scabrous, the lower surface appressed-hairy, somewhat bullate in age, petiole short (scarcely $5 + 3$ mm.), upcurved-hirsute, not winged; spikes opposite the leaves, 3 – 4×50 – 60 mm.; peduncle scarcely 10 mm. long, gray-hirsute; bracts rounded-subpeltate, gray-ciliate; flowers sessile, perfect.

Type in the U. S. National Herbarium, no. 1,209,370, collected at Montserrat, Chiapas, southern Cordillera of Mexico, in 1925, by C. A. Purpus (no. 35).

***Piper eglandulosum*, sp. nov.**

A shrub?; glabrous; flowering internodes long and slender; leaves ovate-elliptic, caudate, equally or subunequally acute at base, 6.5 – 7×15 – 16 cm., pinnately nerved nearly throughout, the nerves some 10 – 12×2 , drying papery and glossy brown; petiole about 1 cm. long, winged at base; spikes opposite the leaves, 4 – 5×70 – 80 mm.; peduncle rather stout, 7 mm. long; bracts inconspicuous; flowers sessile, perfect.

Type in the U. S. National Herbarium, no. 1,230,811, collected at Carapas, Venezuela, alt. 1680 meters, by G. H. H. Tate (no. 14).

***Piper fenianum*, sp. nov.**

A shrub?; flowering internodes crisp-pubescent, rather slender and short (2 – 3 cm.); leaves elliptic-lanceolate, subacuminate, acute at base, small (2×4.5 – 4.5×7 cm.), palmately 5- or the larger obscurely 7-nerved, glabrous above, crisp-hairy beneath; petiole very short (scarcely 5 mm.) and slender, crisp-pubescent; spikes opposite the leaves, 2 – 3×60 – 75 mm.; peduncle "crisp-hairy, short (scarcely 10 mm.); bracts subspatulate, ciliate and somewhat pubescent; flowers perfect, sessile; berries oblong-ovoid, sulcate, glabrous; stigmas 3, sessile.

Type in the U. S. National Herbarium, no. 1,209,377, collected at Hacienda Fenix, Chiapas, southern Sierra Madre, Mexico, in 1925, by C. A. Purpus (no. 386).

Piper martensianum interior, var. nov.

A form with more lance-ovate leaves becoming $5-8 \times 13$ cm.

Type in the U. S. National Herbarium, no. 1,209,374, collected at Monserrate, Chiapas, southern Sierra Madre, Mexico, in 1925, by C. A. Purpus (no. 172). *Purpus* 143 is also this.

Piper purpusianum, sp. nov.

A shrub?; glabrous; twigs zig-zag; flowering internodes rather slender, moderately elongated (3-4 cm.), leaves elongated-lanceolate, subfalcately attenuate, subequilaterally rounded below or acute at the very base, moderate ($3.5 \times 15-5 \times 21$ cm.), pinnately nerved from below the upper fourth, the strongly upcurved nerves $5-9 \times 2$, somewhat bullulate in age, paler beneath; petiole rather short (10-20 mm.), winged to the blade, spikes opposite the leaves, small (4×20 mm.), with sterile apex scarcely 1×10 mm.; peduncle slender and short (scarcely 10 mm.), bracts lunately concave, glabrous, flowers sessile, perfect.

Type in the U. S. National Herbarium, no. 1,209,376, collected at Hacienda Fenix, Chiapas, southern Sierra Madre, Mexico, in 1925, by C. A. Purpus (no. 196).

Piper zarumanum, sp. nov.

A forking shrub, 2m. tall; flowering internodes rather slender and elongated, appressed- or crisp-pubescent; leaves lanceolate or lance-elliptic, somewhat acuminate, subacute at base, small (scarcely 1.75×5.5 cm.), pinnately or submultiple-nerved from below the middle, the nerves 4×2 , minutely appressed-pubescent or scabrid on both sides; petiole 3 mm. long, appressed-pubescent, winged at base, spikes opposite the leaves, $3 \times 30-50$ mm.; peduncle 7 mm. long, crisp-pubescent; bracts triangular-subpeltate, ciliate lacerate; flowers sessile, perfect; berries depressed-globose; stigmas 3, small, sessile.

Type in the U. S. National Herbarium, no. 1,196,222, collected between La Chorrta and Portovelo (gold mine near Zaruma), Province Oro, Ecuador, alt. 1000-2000 meters, August 28, 1923, by A. S. Hitchcock (no. 21178).

Peperomia carapasana, sp. nov.

A rather tall but slender and straggling glabrous herb; stem scarcely 2 cm. thick; leaves characteristically 3 at a node, lance-elliptic, gradually acute at both ends, moderately large ($2.5-4.5 \times 9.5-13$ cm.), 3- or obscurely 5-nerved, drying thin and translucent; petiole 10-15 mm. long, slender; spikes terminal, filiform ($2 \times 90-140$ mm.), densely flowered; peduncle 15 mm. long; bracts round-peltate; berries ovoid-acute with pseudo-cupule; stigma apical.

Type in the U. S. National Herbarium, no. 1,230,868, collected at Carapas, Venezuela, alt. 1680 meters, in 1925, by G. H. H. Tate (no. 114).

Peperomia choritana Trelease, sp. nov.

A small essentially glabrous herb, repent on logs; stem slender (1 mm.); leaves alternate, round to elliptic, rounded at both ends or the longer acute

at base, 7×7 –12 mm., drying thick and yellowish with the simple midnerve evident beneath, somewhat revolute, minutely ciliate upwards, obscurely pale-granular beneath; petiole scarcely 3 mm. long; spikes terminal, 1×40 –50 mm., somewhat openly subannularly flowered; peduncle filiform, 5–10 mm. long; bracts round-peltate; ovary ovoid, pointed; stigma subapical.

Type in the U. S. National Herbarium, no. 1,196,212, collected between La Chorrta and Portovelo (gold mine near Zaruma), Province Oro, Ecuador, alt. 1000–2000 meters, August 28, 1923, by A. S. Hitchcock (no. 21162).

Peperomia enantiostachya distachya, var. nov.

A slender repent and rooting form with ovate-acuminate leaves 2.5×5.5 cm., filiform petioles 1–2.5 cm. long, and very small spikes (in fruit scarcely 1×15 mm.) paired on a filiform 1-bracted common peduncle 2 cm. long, the individual peduncles scarcely half this length; berries ovoid, obliquely long-beaked, the stigma at base of the beak.

Type in the U. S. National Herbarium, no. 1,197 659, collected at Palmera, Rfo Pastaza, between Baños and Mera, Ecuador, alt. 1200 meters, in 1924, by G. H. H. Tate (no. 672).

Peperomia omnicola oblanceolata, var. nov.

A moderate short-stemmed subsimple subprostrate herb; stem rather thick (4 mm.), crisp-pubescent; leaves alternate, oblong-oblanceolate, sharp-acuminate, acute at base, moderately large (5 – 6×15 –17 cm.), sparsely appressed-hairy above, crisp-pubescent beneath especially on the midrib, rather faintly pinnately nerved; petiole 1–2.5 cm. long, crisp-hairy; spikes 2–4 nearly sessile at each node of an open terminal panicle some 15×25 cm., filiform (1×100 –150 mm.); common peduncle (3–4 cm.) and axis of panicle softly crisp-pubescent; bracts round-peltate; ovary ovoid, impressed; stigma subapical.

Type in the U. S. National Herbarium, no. 1,197,654, collected at Palmera, Rfo Pastaza, between Baños and Mera, Ecuador, alt. 1200 meters, in 1924, by G. H. H. Tate (no. 667).

Peperomia ppucu-ppucu, sp. nov.

A moderately small (subprostrate?) glabrous herb rooting from many nodes; leaves crowded, about 3 at a node, round-elliptic, rounded at both ends, often emarginulate, drying opaque and without evident nerves, about 10×10 mm.; petiole short (2 mm.); spikes terminal, about 2×6 mm. rather closely flowered with anastomosing ridges; peduncle short (5 mm.); bracts round-peltate, rather large; berries ovoid-attenuate, with pseudocupule; stigma apical.

Type in the U. S. National Herbarium, no. 1,231,071, collected at Ollantaytambo, Urubamba, Peru, alt. 2300 meters, in 1925, by F. L. Herrera (no. 802).

Peperomia stelecephila glabrata, var. nov.

A moderately small repent herb, on logs, rooting from many nodes; stem rather slender (2–3 mm.), glabrous; leaves alternate, ovate, acuminate, peltate distinctly within the rounded base, 2.5×4.5 cm. (? or larger), dull, leathery, obscurely multiple-nerved, appressed-hairy around the margin; petiole 3 cm. long, glabrous; spikes axillary (? or also terminating lateral

branches), $3 \times 80-90$ mm., closely subannularly flowered, peduncle 25 mm. long, bracted near the middle, bracts round-peltate, berries oblong, truncate with stout spreading beak, stigma on the truncated apex.

Type in the U. S. National Herbarium, no. 1,196,573, collected between Baños and Cachauro, Valley of Río Pastaza, Province Tungurahua, Ecuador, alt. 1300-1800 meters, September 25, 1923, by A. S. Hitchcock (no. 21886).

***Peperomia subanomala*, sp. nov.**

A rather small erect branching herb, stem slender (1-2 mm.) rather long-hairy but glabrescent except about the nodes, leaves opposite, elliptic, sub-acute at both ends, rather small ($7 \times 14-10 \times 20$ mm.), slightly pubescent on the nerves above, somewhat revolute, densely long-hairy beneath, obscurely 3-nerved, firm and opaque; petiole short (2 mm.), hairy or sub-glabrescent, spikes terminal and axillary, moderately small (1×30 mm.), rather closely flowered, peduncle 5 mm. long, glabrous, bracts round-peltate, ovary ovoid, impressed, stigma subapical.

Type in the U. S. National Herbarium, no. 1,197,533, collected at Ambato, Province Tungurahua, Ecuador, alt. 2500 meters, in 1924, by G. H. H. Tate (no. 542).

***Peperomia subconcava*, sp. nov.**

A moderately small more or less caespitose simple erect arborescent herb; stem rather slender (scarcely 2 mm.), at first puberulent or glabrous, leaves about 3 at a node, round-elliptic or obovate, rounded at both ends or the base subacute, very fleshy, drying thick with hyaline margin and not obviously nerved, $10 \times 10-15$ mm., somewhat pubescent to quite glabrous; petiole short (3 mm.) and thick, granular-puberulent or glabrous, inflorescence unknown.

Type in the U. S. National Herbarium, no. 1,196,467, collected between Cuenca and Huigra, Provinces Azuay and Cañar, Ecuador, alt. 2700-3000 meters, September 12-13, 1923, by A. S. Hitchcock (no. 21686).

***Peperomia tequendamana*, sp. nov.**

An ascending moderately small more or less branched herb, stem moderate (2-3 mm.) with short internodes, rusty crisp-villous, leaves alternate (? exceptionally opposite), broadly elliptic or ovate-elliptic, obtuse at both ends or abruptly blunt-acuminate, moderate ($1.5 \times 2.2 \times 4$ cm.), 5-nerved, appressed-hairy on both faces, granular beneath, petiole very short (2 mm.), hairy, spikes terminal and axillary, 2×60 mm., rather loosely subverticillately flowered, peduncle about 10 mm. long, from sparsely crisp-pubescent glabrescent, bracts round-peltate; ovary impressed, ovoid, obtuse, stigma subapical.

Type in the U. S. National Herbarium, no. 1,198,751, collected at Tequendam Falls, near Bogotá, Dept. Cundinamarca, Colombia, September 1909, by Brother Aristide Joseph (no. B-92).

BOTANY.—On *Gyrantthera* and *Bombacopsis*, with a key to the American genera of Bombacaceae. H. PITTIER, Caracas, Venezuela.

In his recent revision of the *Bombacaceae*,¹ Mr. R. C. Bakhuizen van den Brink has confessed himself unable to place my genus *Gyrant-*

¹ *Revisio Bombacacearum*, in Bull. Jard. Bot. Buitenzorg, Ser. III, 6: 161-232; pl. 26-38. 1924.



Fig 1—Flowers of *Gynerthera*: A-C, general views showing details of the petals; D, calyx; E, anther with the connective stipitate and auriculate at the base, long awned at the apex. All about $\frac{1}{3}$ dia

thera, described in 1914 from specimens of the Panaman species.¹ In 1921² I published a second species, *Gyranthera caribensis*, in a paper in which I gave all the additional details necessary to characterize the new genus definitely, and to place it rightly among the *Bombacaceae*. If the author had consulted this paper, presumably accessible to him, the description of the fruit alone would have convinced him that *Gyranthera* really belongs to the *Bombacaceae*, and further that it is not to be associated with *Chorisia*.

In order better to establish the status of *Gyranthera* as a valid genus, its description is given here again, emended and amplified so as to show more clearly the characters which differentiate it. The illustrations, reduced to one-half natural size, show the principal features of the flower and fruit.

DESCRIPTION OF THE GENUS GYRANTHERA PITTIER (1914)

Flores regulares vel leviter zygomorphi. Calyx coriaceus, tubulosus, caducus, plus minusve regulariter 2 vel 3-lobulatus, lobulis perbrevibus, integris bicuspidatisve, in aestivatione valvatis. Petala 5, laciniata, crassa, basi, tubo stamineo adnata, prefloratione contorta. Tubus stamineus teres vel sulcatus, elongatus, gracilis, longe exsertus, apice versus staminodiis lineari-filiformibus plus minusve sparsis appendiculatus; filamenta 5, crassa, antheris permultis, vermiformibus, dithecis obsita; thecae transverse septatae; connectivum basi subsessile vel distincte stipitatum, apice emarginatum ongue mucronatum; pollinis granula pallide flava, laeves, diminuta. Ovarium superum, sessile, 5-carpidiatum, 5-loculare; ovula transversa, anatropa, angulo interno locularum affixa; stylus filiformis, stamina longior, stigmatibus breviter 5-fido. Capsula plus minusve fusiformis, unilocularis, coriacea vel sublignosa; dehiscentia loculicida. Semina numerosa, alata, albuminosa; embryo leviter curvatus.

Arbores sylvarum panamensium et venezuelensium, altae, deciduae, inermes. Folia alterna, 3-7-digitata, longe petiolata, foliolis integris, petiolulatis. Flores magni, albi, ebracteati, in panniculas terminales, unilaterales, dispositi.

From this description it will be seen that *Gyranthera* differs fundamentally from *Chorisia* in its capsule, in which the ovarian cell-walls have been almost completely obliterated; in the shape and disposition of the winged seeds; and especially in the general structure and appearance of the flower. The same conclusion may be more quickly reached by comparing plate 40 of volume 12, part 3, of Martius's *Flora brasiliensis* with the illustrations added to this article. The affinities of the new genus are evidently with the *Matisiae*,—I would say with *Quararibea* and *Ochroma* with regard to the floral

¹ *Maleales novae panamenses*, in Repert. Nov. Sp. Fedde 13: 318. 1914.

² *Acerca del genero Gyranthera Pittier*, in Bol. Com. Ind. Venezuela 13: 417-433. 1921.

structure, and with *Bernoullia* as to the fruits. But our plant differs from all three in its digitate leaves and from each in particular by decidedly aberrant characteristics, such as the presence of staminodes disposed in two more or less regular whorls, each staminode simple or bifurcated in the upper whorl, bifid or trifid in the lower whorl. The arrangement of the seeds also is remarkable and *sui generis*: while in *Bernoullia*, the wings are simply turned upward at the base and downward at the apex of each cell of the capsule, in *Gyranthera* they are so placed in the single cell that two consecutive wings of the lower seeds are separated by the wing of one of the upper ones. This is neatly shown in figure B, of the accompanying Fig. 2.

The above description is far from perfect. The arrangement of the anthers, on account of their peculiar gelatinous consistency when fresh, has not yet been sufficiently elucidated. The fruit of the Panaman species is not known. But it seems that there can be no doubt as to the validity of the genus and its place in the classification, somewhere between *Quararibea* and *Bernoullia*.

Mr. Bakhuizen van den Brink also ignores the genus *Bombacopsis*, published by me in 1916, based on *Pachira Fendleri*.⁴ I am quite aware that any botanist who is reduced to mere herbarium specimens or scanty descriptions upon which to base his judgment may hesitate to accept any further splitting of the genera *Bombax* and *Pachira*. Schumann himself even went so far as to unite these two last groups into a single one, *Bombax*, thus going back to the Linnean generic concept. This, however, has not generally been accepted, and most botanists admit that there is at least a decided difference between the two groups. They are as a matter of fact separated by fundamental differences in the fruit and seed, and by no small structural details of the flowers. Without going farther into details, let us recall the presence or absence of wool in the fruit and the considerable size of the seeds of *Pachira* as compared with those of *Bombax*.

In the course of my explorations in Panama, my attention was drawn to two striking trees, originally placed among the species of *Pachira*, the one by Seemann under the name of *P. Fendleri*, the other by Benthham as *P. sessilis*, and transferred to *Bombax* by subsequent authors. The flowers of these two trees look exactly like miniatures of those of the genus *Pachira* and, as the fruits had not then been described, both botanists were to a certain extent justified in the generic place assigned to these species. But when the fruits became known, they proved to have the structure of those of *Bombax*.

⁴ Contr. U. S. Nat. Herb. 18: 159-163, pl. 64-75 1916

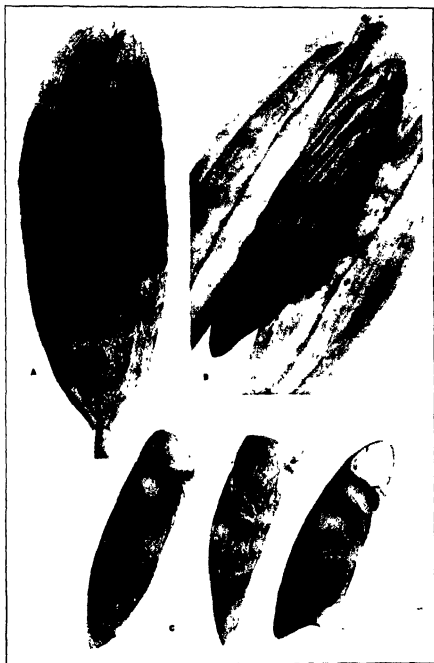


Fig. 2—Fruit of *Gyranthera*: A, capsule before dehiscence, B, part of open capsule showing arrangement of seeds, C, detached seeds, one open to show details of embryo. Same reduction as in Fig. 1

with small seeds imbedded in the wool depending from the pericarp. That is to say, these trees, on account of their fruits, do not belong to *Pachira* nor, because of the characteristics of the flowers, to *Bombar*. In other words, they belong neither to *Bombar* nor *Pachira*. The simplest solution was, then, to create an intermediary genus, and this is what I did under the name *Bombacopsis*.

As a general rule, I do not believe in the multiplication of generic names at the expense of well-established groups, but that there are cases when the necessity of the division becomes more and more obvious. Two good instances have attracted my attention in the course of an experience of nearly forty years in neotropical botany. I refer to the genera *Pithecolobium* and *Cassia*. When one comes to know the species of the first by daily observation, ordinary common sense leads one to separate them into several groups. There is certainly no macroscopic likeness between a *Pithecolobium* of the *unguis-cati* group and the rain-tree (*P. saman* Benth.), and again, it is difficult to see the direct parental connection of the latter with the sections *Caulanthos* and *Chloroleucon* as created by Bentham.

I think that Merrill was right when he proposed to make *Pithecolobium saman* the type of the distinct genus *Samanea*,^{*} and so I have followed him in naming several recently described species. Britton and Rose are now trying to effect an analogous division in the compound genus *Cassia*, and it is to be hoped that their views will be accepted, at least along general lines. These same authors, however, have not always been very moderate in their views. Few botanists, I think, would agree to accept their extreme splitting of certain genera of *Cactaceae*, in which each section has been proposed as a genus.

To return to *Bombacopsis*, let us repeat that in this group the flower, notwithstanding its likeness to that of *Pachira*, differs markedly in its size, in the longer and narrower calyx, in the number and branching of the stamens, as well as in the wool-bearing fruit and the smaller dimensions of the seeds. On the other hand, if the fruit compares with that of *Bombar* in its general characteristics, the dehiscence is apical with the valves, coriaceous or at least thin, adhering to the receptacle, while in *Bombar* these valves are woody and thick and detach themselves piece after piece from the fruit. The flowers, also, have at most 200 stamens and often not more than 75, while up to 1400 have been counted in some individual *Bombar* flowers.

These are the more distinctive botanical features which separate

* THIS JOURNAL 6: 47. 1916

the three genera. But in the field nobody would confuse a *Bombax* tree, with its relatively short, thick or ventricose trunk, nor a middle-sized, leafy *Pachira*, with the often enormous individuals of *Bombacopsis*, with its straight column or trunk and sparsely leaved crown towering among the highest in the forest. In *Pachira* and *Bombax* the wood is white and soft and the bark smooth; in *Bombacopsis* the core of the former is reddish and much harder, and the bark, rough and rimose, is often covered with numerous, stout aculei. More details and many illustrations will be found in the place of the original description.

As is natural, I have expanded on the two genera *Gyranthera* and *Bombacopsis*, because, as my own creations, I had their defense very much at heart. It seems almost impossible not to recognize the validity of *Gyranthera*; and as to *Bombacopsis*, which I find necessary as a transitory link between *Bombax* and *Pachira*, its acceptance depends mainly upon whether the two latter genera remain separated, as seems best, or whether the view of Schumann is to be maintained. Most American botanists adopt the former view and so does Urban in his *Symbolae Antillanae*⁴ and Mr. Backhuizen in his "Revisio."

In the latter we note the presence of genus *Montezuma*, as "arbor mexicana." As shown by Standley and Urban⁵ as early as 1921, the species probably was never found in Mexico and is identical with the Porto Rican *Thespesia grandiflora*, the type of Urban's new genus *Maga*. *Montezuma* is recognized as belonging to the *Malvaceae* and must be dropped from the *Bombacaceae*. On the other hand, Backhuizen does not mention *Spirotheca*, separated from *Ceiba* prior to 1924 by Ulbrich,⁶ who also described in October of that year another Austro-American genus *Septotheca*.⁷

As known today, the American genera of the *Bombacaceae* may be tentatively keyed as follows:

Fruit capsular, dehiscent, large, 5-celled or, in one case 1-celled on account of the disappearance of the walls; calyx caducous; seeds numerous.

Seeds round and smooth, exalate; leaves digitate or, in one case, palmate (*Bombacineae*)

Seeds large (1.5 cm. in diam. or more), imbedded in the fleshy dissepiments of the endocarp; flowers large and long (up to 35 cm.); stamens numerous; filaments repeatedly dichotomous; leaves digitate.....1. *Pachira*

⁴ Vol. 8, page 427.

⁵ Notisbl. Bot. Gart. Mus. Berlin 7: 543. 1921.

⁶ Ibid. 6: 100. 1914.

⁷ Ibid. 9: 128. 1924.

Seeds small (not over 1 cm. in diam.), surrounded by wool derived from the endocarp.

Fertile stamens numerous, the upper part of the filaments free, simple or bifurcated, without appendices or staminodes.

Flowers slender and long (up to 15 cm.); stamens 75-200; capsule ovoid or pentagonous 18 cm. long or less. . . 2. *Bombacopsis*

Flowers thick and short, the stamens very numerous (up to 1400); capsule fusiform, 15 cm. long or more. 3. *Bombax*

Fertile stamens 5 or 10, more or less adnate; staminodes sometimes present.

Stamens 5, the upper part of the filaments free.

Calyx 3-5-lobed, anthers simple, certain species with staminodes. 4. *Ceiba*

Calyx truncate; anthers double; no staminodes. . . 5. *Spirotheca*

Stamens with the filaments completely adnate.

Anthers 10, straight; gynophor with a cuff-like whorl of 5-bifid staminodes, leaves digitate 6. *Chorisia*

Anthers 5, vermiform; no staminodes; leaves palmately-lobed. 7. *Ochroma*

Seeds winged; calyx more or less regularly 2-5-lobed; leaves digitate (*Gyrantherae*).

Capsule 1-celled, with 8-12 seeds in all; staminal tube closed nearly to the apex; anthers vermiform; staminodes present. . . 8. *Gyranthera*

Capsule 5-celled, with 8-12 seeds in each cell; staminal tube split open almost from the base; anthers short, oblong; no staminodes.

9. *Bernoulhia*

Fruit drupaceous, samaroid or capsular, but small; seeds 1-5; calyx mostly persistent; stamens mostly adnate, the anthers 1-celled; leaves simple, trinerved (*Matisiae*).

Stamens united in 5 bundles; fruit samaroid. 10. *Cavanillesia*

Stamens united in a single tube.

Staminal tube very short, the upper part of the filaments free and bearing a simple anther; fruit capsular.

Calyx truncate; filaments evenly thin. 11. *Hampea*

Calyx 5-partite; filaments thicker toward the apex . . 12. *Catostemma*

Staminal tube long, more or less deeply 5-partite at the apex, this covered with sessile anthers.

Staminal tube with 5 apical teeth; anthers 30-40; fruit subcapsular. 13. *Quararibea*

Staminal tube 5-branched at the apex.

Anthers 6-12, ovate-oblong, undivided; fruit drupaceous. 14. *Matisia*

Anthers more numerous, vermiform, irregularly divided into several cells. 5. *Septotheca*

BOTANY.—*New South American Verbesininae.*¹ S. F. BLAKE, Bureau of Plant Industry.

Of the thirteen new species of South American Verbesininae described in this paper, seven are based on specimens from the extensive collections made in northern Peru by J. Francis Macbride and William Featherstone on the Capt. Marshall Field expeditions sent out by the Field Museum of Chicago. Three of the others are from a small collection made by G. H. H. Tate, of the American Museum of Natural History, in the mountains of northeastern Venezuela, and one is from the Colombian collections of Dr. F. W. Pennell. The two remaining species are based on old specimens in the Kew Herbarium, collected by William Purdie and A. Mathews in Colombia and Peru respectively, and lent the writer for study by the Director of Kew Gardens, Dr. A. W. Hill.

Jaegeria axillaris Blake, sp. nov.

Small glabrous herb, repent at base; leaves lance-elliptic, connate-clasping, serrulate; heads small, solitary, axillary, on peduncles shorter than the leaves; rays 5, usually shorter than the narrowed tips of the phyllaries.

Perennial (?), 15 cm. long or less, light green, simple or sparsely branched, repent below, the tips apparently ascending; internodes 3 to 30 mm. long; leaves opposite, lance-elliptic, 1.2 to 1.8 cm. long, 3 to 7 mm. wide, narrowed to the callous obtuse apex, cuneate-rounded and connate at base, remotely serrulate with blunt callous teeth or subentire, 3-ple- or 5-plinerved and reticulate (the veins conspicuous in transmitted light); peduncles slender, erect, 3 to 10 mm. long; heads 3.5 to 4 mm. high, 2.5 to 4.5 mm. wide, phyllaries 5, lance-ovate (in their natural position), with subherbaceous 3 to 5-nerved body, glabrous dorsally, hirsute on the sides, and thin scarious ciliate margins infolded about the achenes, abruptly contracted above, and more or less 3-lobate, the central lobe subherbaceous, triangular, acuminate to an obtuse apex, erect to spreading, 1 to 1.5 mm. long; rays 5, light yellow, fertile, essentially glabrous, the tube 0.4 mm. long, the lamina suborbicular, 1.2 mm. long and wide, 3-dentate, 3 to 5-nerved; disk flowers 8, their corollas pale yellow, sparsely pilose on tube, 4 or 5-toothed, 1.5 mm. long (tube 0.4 mm., throat campanulate, 0.8 mm., teeth deltoid, 0.3 mm.); pales broad, abruptly short-pointed, erose above, about 7-nerved, 3.5 mm. long; ray achenes oblong, 2.2 mm. long, obcompressed, blackish, glabrous, bearing a callous half-collar 0.1 mm. high at apex, disk achenes compressed or subquadrangular, 2.2 mm. long, blackish, glabrous, bearing a very short apical collar.

Type in the herbarium of the New York Botanical Garden, collected in wet meadows southwest of Las Cruces, Bogotá, Dept. Cundinamarca, Colombia, alt. 2600-2700 meters, September 24-25, 1917, by F. W. Pennell (no. 2171). Duplicate in U. S. National Herbarium, no. 1,042,157.

When the internodes are short and the leaves crowded the plant is suggestive of *Aphanactis jamesoniana* Wedd. in appearance.

¹ Received March 9, 1926.

Aphanactis villosa Blake, sp. nov.

Cespitose perennial, densely flavescent-villous; leaves crowded, narrowly elliptic, entire, 3-nerved; peduncles becoming 2 cm. long; phyllaries densely villous at least above.

Stems several, prostrate or ascending, 6 cm. long or less, branched, slender, densely flavescent-villous; internodes at first very short, becoming 4 to 12 mm. long; leaves opposite, sessile, contracted into sheathing, scarious, glabrate or glabrescent, connate bases, obtusely callous-tipped, 3 to 5-plinerved, thickish, the lower up to 13 mm. long, 4 mm. wide, the middle and upper smaller, elliptic or elliptic-spatulate, 4 to 9 mm. long, 1.5 to 2.5 mm. wide, all densely flavescent-villous; heads subglobose, about 3.5 mm. high and thick, solitary, axillary and terminal, in anthesis subsessile, the peduncles in age becoming 2 cm. long, naked or bearing a leafy bract, phyllaries 6, about 2-seriate, appressed, the outermost one shorter, ovate, acutish, 2.8 mm. long, 1.5 mm. wide, 5-nerved, subherbaceous except for the slightly indurated base, densely villous and ciliate, the next 4 equal, broadly oval, obtuse, 3 mm. long, 2 mm. wide, with similar texture and pubescence, the innermost one oblong, 3 mm. long, 1.5 mm. wide, pilose along middle, scarious-margined, not ciliate, erose at tip; receptacular pales aristiform-subulate, about 2.5 mm. long, 0.2 mm. wide toward base, glabrous, 1-nerved; pistillate corollas 5, greenish yellow, densely long-villous on tube, sparsely so on limb, barely surpassing the involucre, 2.2 mm. long (tube 1.5 mm., lamina erect, cuneate, 3-toothed, 0.7 mm. long and about as wide); disk corollas 3 or 4, greenish yellow, densely long-villous on tube, glabrous above, 4 or 5-toothed, 1.8 mm. long (tube 0.7 mm., throat slightly broader, 0.7 mm., teeth deltoid, 0.4 mm.); ray achenes obovoid-oblong, 1.4 mm. long, plump, biconvex, slightly obcompressed, obscurely about 5-angled, glabrous, fuscous, epappose; disk achenes obovoid or elliptic-oblong, 1.2 to 1.5 mm. long, somewhat compressed, about 4-angled, multistriatulate, glabrous, epappose.

Type in the herbarium of the Field Museum, no. 534367, collected on grassy subalpine slopes at Chasqui, Dept. Huánuco, Peru, April 10, 1923, by J. F. Macbride (no. 3297). Duplicate in the U. S. National Herbarium, no. 1,191,439.

Readily distinguished by its dense pubescence and at length elongate peduncles. The genus, of which only one species has hitherto been described, has not previously been known south of Ecuador.

Montanoa lehmannii (Hieron.) Blake.

Eriocoma (*Montanoa*) *lehmannii* Hieron. Bot. Jahrb. Engler 19: 54. 1894.

Related to *Montanoa quadrangularis* Schultz Bip. In *M. lehmannii* the leaves are densely prominulous-reticulate beneath, and the fruiting pales are provided at the retuse apex with a comparatively short and stout cusp about 0.5 mm. long. In *M. quadrangularis* the leaves are not densely prominulous-reticulate beneath, and the retuse fruiting pales have a slender, longer cusp, usually 1 to 1.5 mm. long. Specimens collected by M. T. Dawe (no. 700) in the Kew Herbarium show that the "arboloco" recently described by him¹ as an important source of timber and wood for billiard cues in Colombia is *M. lehmannii* and not *M. moritziana* Schultz Bip., as which his specimens were identified at Kew. The latter name, which has never been published with a description, belongs in the synonymy of *M. quadrangularis*.

¹ See Record, *Tropical Woods* 2: 13. 1925.

A photograph and fragments of a specimen in the Kew Herbarium of *Lehmann* 7480, type collection of *E. lehmannii*, are now in the National Herbarium.

Viguiera leptodonta Blake, sp. nov.

Section *Diplostichis*; herb; stem loosely sordid-pilose; leaves opposite, ovate, slender-petioled, hirsute-pilose; heads small, several or numerous in terminal cymose panicles; involucre strigillose, 5 mm. high; achenes sparsely hispidulous; pappus of 2 awns and usually 4 narrow squamellae.

Stem subterete (3 to 4.5 mm. thick), 65 cm. high and more, probably lax or sprawling, branched, striate, white-pithy, loosely and rather densely pilose with dull white, several-celled, spreading hairs, glabrescent below, internodes 4 to 14.5 cm. long; leaves opposite essentially throughout; petioles slender, naked, densely hirsute-pilose, glabrescent, 1 to 2.5 cm. long, blades ovate, 6 to 11.5 cm. long, 2.5 to 6.5 cm. wide, acuminate, somewhat falcate, at base broadly rounded to cuneate-rounded, crenate-serrate practically throughout (teeth depressed, 3 to 4 per cm., the apiculate tips about 0.5 mm. long), membranous, above dark green, evenly but not densely hirsute with somewhat antrorse-curved white hairs with small tuberculate bases, beneath slightly lighter green, evenly but not densely hirsute-pilose on surface with spreading scarcely tuberculate-based hairs, densely so along the veins, tripli- or quintuplinerved essentially from base and loosely prominulose-reticulate; panicles terminating stem and branches, usually ternately divided, 3.5 to 7 cm. wide, about 15-headed, the principal branches subtended by somewhat reduced leaves, the other bracts filiform, 7 mm. long or less, the chief branches pubescent like the stem, the pedicels densely appressed-pubescent, 4 to 15 mm. long; heads 1.5 to 2 cm. wide; disk at first cylindric-oblong, becoming subglobose in fruit, in flower 8 to 10 mm. high, 5 to 7 mm. thick, in fruit about 1 cm. thick; involucre 2-seriate, equal or slightly unequal, 4.5 to 5 mm. high, the phyllaries 10, lanceolate or lance-ovate (1 to 1.5 mm. wide), sharply acuminate, subherbaceous, blackish green, densely strigillose, the outer with somewhat divergent tips; rays 8, yellow, neutral, pilose on tube and on nerves of back, the tube 1.5 mm. long, the lamina elliptic, 2-denticulate, 10 mm. long, 3 mm. wide, 7-nerved; disk flowers about 21, their corollas yellow, finely hispidulous throughout, short-hirsute on teeth, 6.5 mm. long (tube 1.3 mm., throat cylindric, 4.3 mm., teeth ovate, 0.9 mm.); pales acute, mucronulate, blackish green with scarious margins, hispidulous along middle, 7 mm. long; ray achenes (inane) trigonous, hispidulous, epappose; disk achenes obovate, strongly compressed, sparsely hispidulous especially above, 3 mm. long, 1.2 mm. wide; awns 2, slender, subequal, denticulate below, 4 mm. long; squamellae lanceolate, acute, lacerate, 1.5 to 2 mm. long, a pair at base of each awn and often 1 or 2 much smaller ones on one side between them.

Type in the U. S. National Herbarium, no. 1,230,823, collected along dry trail at Carapas, Sucre, Venezuela, alt. 1680 meters, in 1925, by G. H. H. Tate (no. 27). Additional specimen, with same data, collected under no. 26.

The only species of *Viguiera* hitherto known from Venezuela is *V. mucronata* Blake, to which and to *V. anomala* Blake, of Colombia, *V. leptodonta* is most closely related. In *V. mucronata* the stem hairs are all or mostly appressed, the achenes densely silky-pilose, the squamellae 4, broad and rounded, covering the whole apex of achene, and the disk corollas much shorter. In *V. anomala* the stem pubescence is denser and more sordid, the heads are narrower and fewer-flowered, and the achene is glabrous. The name of the new species refers to the slender apiculations of the leaf-teeth.

Viguiera pusilla astephana Blake, var. nov.

Achenes glabrous, epappose; otherwise as in the typical form.

Type in the herbarium of the Field Museum, no. 534812 (in part), collected in loose soil on slopes, Yanano, Dept. Huánuco, Peru, alt. about 1830 meters, May 13-16, 1923, by J. F. Macbride (no. 3750 in part). Duplicate in the U. S. National Herbarium, no. 1,191,464 (in part).

The sheet in the Field Museum bears 3 specimens, one with the pappus and pubescent achene of *Viguiera pusilla* (A. Gray) Blake, the others precisely similar except for the glabrous, epappose achenes. The National Herbarium sheet bears one specimen of each form. The plant is of particular interest from the fact that no epappose form has hitherto been known in the large section *Paradosa*, including nearly half the species of the genus.

Viguiera macbridei Blake, sp. nov.

Series *Aureae*; stems stout, very leafy, densely and canescently spreading-pilose; leaves alternate, narrowly lanceolate, acuminate, short-petioled, revolute-margined, bullate above, densely and canescently pilose-tomentose beneath; heads several or numerous, cymose-panicled, medium-sized; involucre graduate, 7 to 9 mm. high, hispid-pilose.

Herb, 1.3 to 1.6 m. high, several-stemmed; stems strict, subterete (4 to 8 mm. thick), striatulate, pithy, glabrate below, above densely pilose or hirsute-pilose with spreading or loosely reflexed white hairs 2 to 4 mm. long, with small tuberculate bases, and between them appressed- or ascending-pilose with shorter hairs; internodes mostly 3 to 10 mm. long, leaves alternate (except perhaps at extreme base); petioles stout, naked, 1 to 2 mm. long, densely hispid-pilose like the stem; blades narrow-lanceolate or linear-lanceolate, 5 to 6.5 cm. long, 5 to 13 mm. wide, acuminate, cuneate or rounded at base, subentire, strongly revolute-margined, subcoriaceous, above dark green, shining in age, harshly pilose-hispid with tuberculate-based antrorse hairs, beneath densely and canescently pilose-tomentose (the costa glabrate except for the persistent tuberculate hair-bases), triplinerved and with numerous pairs of lateral veins, these impressed above, mostly concealed beneath by the tomentum; heads about 2.8 cm. wide, 5 to 16 at apex of stem, terminal and on 1 to 4-headed axillary branches 5 to 15 cm. long, bearing reduced leaves, the pedicels or peduncles 4 cm. long or less; disk subglobose, 1 to 1.5 cm. high, 1 to 1.8 cm. thick; involucre 3 to 4-seriate, graduate, 7 to 9 mm. high, the phyllaries oblong-ovate to oblong (2 to 3 mm. wide), acute, appressed or with short spreading tips (glabrous inside), blackish green and subherbaceous with paler, more indurate base, 1-ribbed, densely hispid-pilose and ciliate with subappressed partly deciduous hairs with persistent tuberculate bases; receptacle rounded; rays about 8, golden yellow, neutral, pubescent on tube and nerves of back, the tube 1.3 mm. long, the lamina oval, 16 mm. long, 7.5 mm. wide, 3-denticulate, 12 or 13-nerved; disk flowers very numerous, their corollas yellow, pubescent chiefly on tube, base of throat, and back of teeth, 5.2 to 6.2 mm long (tube 1.2 to 1.8 mm., throat cylindric, 2.8 to 3.2 mm., teeth ovate, papillose-margined, 1 to 1.2 mm.); pales acute, carinate, blackish green and hispidulous above, 9 mm. long; ray achenes (inane) trigonous, with a pappus of about 6 lacerate squamellae up to 1.2 mm. long; disk achenes obovate-oblong, compressed, blackish, rather sparsely subappressed-pilose, 4 mm. long, 1.2 mm. wide; awns 2, slender, hispidulous, very unequal, 1.8 to 3 mm. long; squamellae of each side of achene connate into a lacerate scale 1 mm. long.

Type in the herbarium of the Field Museum, no. 535145, collected on steep rocky western grasslands, Huacachi, near Mufia, Dept. Huánuco, Peru, alt. about 1980 meters, May 20-June 1, 1923, by J. F. Macbride (no. 4078). Duplicate in U. S. National Herbarium, no. 1,191,485.

A very distinct species of the Subseries *Euaureae*, related to *Viguiera sodiroi* (Hieron.) Blake and *V. mollis* Griseb., of Ecuador and Argentina respectively, but distinguished from both by its narrowly lanceolate leaves, as well as by other characters.

***Helianthus acuminatus* Blake, sp. nov.**

Shrub; young branches densely griseous-pilose, leaves opposite, ovate, slender-petioled, acuminate, rounded at base, subentire, densely griseous-tomentose beneath; heads rather large; involucre about 13 mm. high, of oblong, acute or acuminate, cinerascens-puberulous and sparsely pilose phyllaries; disk corollas yellow or yellowish throughout.

Apparently tall; stem stout (up to 6 mm. thick), subterete, striatulate, glabrous or glabrate, with mostly opposite branches; young branches very densely pilose, almost tomentose, with mostly spreading whitish or griseous hairs with small tuberculate bases; internodes of main stem 6 to 10 cm. long, of the young leafy branches 1 to 2 cm.; leaves opposite practically throughout except in the inflorescence; petioles 0.8 to 1.8 cm. long, slender, densely pilose-subtomentose; blades ovate, 4 to 7 cm. long, 2.8 to 4.3 cm. wide, falcate-acuminate, at base broadly rounded, subtruncate, or subcordate, very shortly or not at all decurrent on the petiole, obscurely serrulate (teeth 4 to 5 per cm.) or subentire, firm, above green or blackish green, densely and rather softly short-pilose with antrorse, shining hairs with small glandular-tuberculate bases, beneath densely and softly griseous-tomentose, triplinerved essentially from base, heads about 3.8 cm. wide, axillary and terminal, 1 to 5 toward tips of stem and branches, on stout upwardly somewhat thickened spreading-pilose peduncles 1 to 14 cm. long; disk subglobose, 1.3 to 1.5 cm. high, 1.2 to 2 cm. thick; involucre about 4-seriate, graduate, 1.2 to 1.4 cm. high, the phyllaries oblong (2.8 to, in age, 5.5 mm. wide), acute or acuminate, blackish green, obscurely herbaceous above, the inner with loose tips, all densely and cinerascens appressed-puberulous and pilosulous, somewhat pilose above, glabrescent in age, about 3-nerved; rays 14 or more, yellow, neutral, pubescent on tube and nerves of back, the tube 2 mm. long, the lamina oblong-elliptic, 2-dentate, 2 cm. long, 6 mm. wide; disk corollas yellow throughout or greenish on the teeth, pilosulous chiefly toward base of tube, along nerves above, and on teeth, 7.5 mm. long (tube 1.5 mm., throat cylindric, 5.2 mm., teeth deltoid, 0.8 mm.); pales acute, usually mucronulate, pilosulous chiefly along the narrow keel above, 11 mm. long; achenes oblong-obovate, compressed, blackish, glabrous, 3.8 mm. long, 1.5 mm. wide; awns 2, lanceolate, hispidulous-ciliate, caducous, 3 mm. long; rays achenes (inane) with 2 less caducous, lacinate squamellae 1 mm. long.

Type in the herbarium of the Field Museum, no. 518863, collected on open, moist, rocky slope at Tomaiquichua, a pueblo three miles below Ambo, Dept. Huánuco, Peru, alt. about 2590 meters, September 19, 1922, by J. F. Macbride and W. Featherstone (no. 2429). Duplicate in U. S. National Herbarium, no. 1,198,894.

Allied to *Helianthus grandiceps* Blake, of Ecuador, which has alternate leaves with cuneate or rounded-cuneate base, more definitely toothed, and with the lateral nerves arising distinctly above the base, and longer involucre;

also to *H. jelskii* Hieron., of Peru, in which the leaves are much thicker, and densely ochroleucous-lanate-tomentose and lacunose-reticulate beneath.

***Helianthus discolor* Blake, sp. nov.**

Shrub; branches appressed-pilose, glabrate or glabrescent; leaves opposite below, alternate above, often with axillary fascicles, linear-lanceolate or linear, 3.8 cm. long or less, greenish and strigose above, beneath white-tomentose; heads solitary at tips of stem and branches, medium-sized; involucre 9 mm. high, of lanceolate or lance-oblong, cinereously appressed-pubescent phyllaries, only their extreme tips loose; disk corollas yellow, with fuscous teeth.

Stems in clumps from a caudex, 40 cm. long and more, slender (2.5 mm. thick or less), alternate-branched, gray-barked, glabrate; branches thinly appressed-pilose, somewhat glandular, and toward the nodes often tuberculate-hispid; petioles pilose, 1.5 mm. long or less; blades of the principal leaves 2.3 to 3.8 cm. long, 4 to 6 mm. wide, usually acuminate to an obtuse apex, cuneate at base, somewhat falcate, entire or subentire, revolute-margined, subcoriaceous, above dull green, rather densely strigose to sparsely hispidulous with glandular-tuberculate-based hairs, somewhat glabrescent, beneath densely and loosely white-tomentose, triplinerved near base and feather-veined, the veins impressed above, evident beneath through the tomentum in age; leaves of the fascicles linear, about 1.5 cm. long, 1.5 mm. wide, or smaller, peduncles terminating stem and branches, 3 to 7 cm. long, naked or few-bracted, sordid-pilose and sparsely hispid below the heads; heads 3.5 cm. wide or less; disk hemispheric, 9 to (fruit) 14 mm. high, 1 to (fruit) 2 cm. thick (as pressed); involucre 3 to 4-seriate, graduate, 8 to 9 mm. high, the phyllaries lanceolate or oblong (outer) to oblong-lanceolate (the inner 1.5 to 2.5 mm. wide), appressed or (especially the outer) with spreading tips, the outer subherbaceous essentially throughout, densely appressed-pilose and somewhat hirsute, the others indurate and blackish below and there nearly glabrous except for the hirsute-ciliate margin, with shorter or longer obtuse to acutish herbaceous tips, these densely appressed-pilose, more or less ciliate, and somewhat glandular; rays about 9, yellow, neutral, pubescent on tube and on nerves of back, glandular between them, the tube 1 mm. long, the lamina oblong, 2-toothed, about 10-nerved, 15 mm. long, 5 mm. wide; disk corollas puberulous on lower part of tube, on nerves above, and on teeth, 7.3 mm. long (tube 1.2 mm., throat cylindric, 5 mm., teeth ovate, 1.1 mm.); pales acuminate, often mucronulate, blackish above along costa, hispidulous above along keel and ciliate, about 9 mm. long; achenes oblong-obovate, compressed, glabrous, 3.3 mm. long, 1.5 mm. wide; awns 2, linear-subulate, hispidulous, caducous, about 2 mm. long.

Type in the herbarium of the Field Museum, no. 518724, collected on eastern side of canyon at Llata, Dept. Huánuco, Peru, alt. about 2135 meters, August 21, 1922, by J. F. Macbride and W. Featherstone (no. 2240). Duplicate in the U. S. National Herbarium, no. 1,198,892.

Allied to *Helianthus microphyllus* H. B. K. and *H. subniveus* Blake (*H. niveus* Hieron., not Brandeg.). In the former the involucre is only 5 mm. high, with oblong, apically tomentose phyllaries; in the latter it is 1 cm. long, and densely niveo-tomentose.

***Helianthus senex* Blake, sp. nov.**

Shrub; branches canescently long-villous, glabrescent; leaves mostly

opposite, broadly ovate, serrulate, petioled, cinereous-pilose above, densely white-tomentose beneath; heads medium-sized, solitary on axillary and terminal peduncles; involucre 8 mm. high, graduate, the phyllaries oblong, obtuse, canescent-tomentose especially above; disk corollas yellow throughout.

Shrub 1 meter high, growing in clumps; stem stout (4 to 7 mm. thick), with opposite or alternate branches, terete, in age glabrate and conspicuously lenticellate; branches very densely long-villous with loosely spreading or reflexed white hairs 2 to 3 mm. long and with slightly enlarged bases, glabrescent, striatulate; internodes mostly 0.5 to 2.5 cm. long; leaves chiefly opposite, alternate above on the flowering branches; petioles stout, 5 to 15 mm. long, unmarginated, densely pilose-tomentose; blades ovate, the larger 5 to 6.5 cm. long, 3 to 4 cm. wide, acute, broadly rounded at base and very shortly decurrent on the petiole, serrulate or crenate-serrulate above the entire base (teeth about 4 per cm.), thick-herbaceous, above densely cinereous-pilose with mostly spreading hairs with small glandular-tuberculate bases, beneath very densely and softly white-tomentose, triplinerved from near the base, the principal veins at first impressed, later prominulous above, beneath at length evident beneath the tomentum; branch leaves often smaller, yellowish above; peduncles axillary and terminal, 2 to 5 toward tips of branches, normally 1-headed, spreading-pilose, glabrescent, naked or few-bracted, 2 to 8 cm. long; heads 2 cm. wide; disk subglobose, 1 to 1.3 cm. high, 8 to 15 mm. thick; involucre 3 to 4-seriate, graduate, 7 to 8 mm. high, the phyllaries appressed or with very short spreading tips, oblong (1.3 to 2 mm. wide) or the outer oblong-ovate, obtuse, with indurated, blackish, pale-margined, glabrate (in the inner nearly glabrous) base and shorter, densely pilose-tomentose, herbaceous apex; rays about 8, small, yellow, neutral, pilose on tube and on nerves of back, the tube 1.5 mm. long, the lamina elliptic-oblong, 5 to 10 mm. long, 2 to 4 mm. wide, 3 or 4-denticulate, 9-nerved, sometimes bearing at base 2 appendages suggesting abortive stamens; disk corollas sparsely hispidulous chiefly on nerves above and on teeth, 6.3 mm. long (tube 1.3 mm., throat cylindric, 4.5 mm., teeth deltoid, 0.5 mm.); pales acute or acutish, callous-apiculate, not keeled, pilose and ciliate above, 11 mm. long or less; achenes oblong, compressed, blackish, glabrous, 3.5 mm. long, 1.3 mm. wide; awns 2, linear-lanceolate, hispidulous-serrulate, caducous, 3 mm. long.

Type in the herbarium of the Field Museum, no. 518,077, collected on canyon slope at Mito, Dept. Huánuco, Peru, alt. about 2745 meters, July 8-22, 1922, by J. F. Macbride and W. Featherstone (no. 1572). Duplicate in the U. S. National Herbarium, no. 1,198,884.

Nearest *Helianthus imbaburensis* Hieron., of Ecuador, which has alternate, acuminate, entire leaves and shorter sub-2-seriate involucre of more densely and uniformly pilose-tomentose phyllaries.

Helianthus viridior Blake, sp. nov.

Shrub, much branched, very leafy; branches appressed-pilose, glabrate; leaves chiefly alternate, lanceolate, short-petioled, subentire, appressed-subsericeous when young, soon glabrescent and green on both sides; heads medium-sized, solitary; involucre 1 cm. high, of lanceolate or lance-ovate acuminate phyllaries, densely pilose above; disk corollas with fuscous teeth.

Stem terete (5 mm. thick), gray-barked, lenticellate, glabrous, apparently procumbent, 30 cm. long and more, sending out numerous mostly simple or subsimple alternate ascending branches nearly or quite as long; young

branches warty, not densely appressed-pilose, the older gray-barked, glabrate or glabrescent; internodes on the older portions mostly 1 to 5 mm. long, on the younger mostly 1 to 2.5 cm.; leaves opposite at base of branches, alternate above; petioles slender, naked, appressed- or erectish-pilose, 3 to 8 mm. long; blades lanceolate, 3 to 4.3 cm. long, 5 to 13 mm. wide, acuminate to acutish, callous-apiculate, cuneate at base, entire or obscurely serrulate mostly above the middle, rather thin, triplinerved above the base, scarcely reticulate, above at first canescently subsericeous-pilose with appressed hairs, soon glabrescent, green, and evenly appressed- or antrorse-pilose (the hairs with scarcely enlarged glandular bases), beneath at first densely and canescently appressed-silky-pilose, soon green and loosely antrorse-pilose, usually narrowly revolute on margin; peduncles solitary, terminating stem and branches, 1-headed, appressed-pilose, naked or few-bracteate, 3.5 to 5 cm. long; heads about 3 cm. wide; disk subglobose, 1 to 1.3 cm. high and thick, involucre 3 to 4-seriate, graduate, 8 to 11 mm. high, the phyllaries lanceolate or linear-lanceolate (outer) to lance-ovate, mostly acuminate, with short callous blackish tips, rather densely and loosely pilose on their exposed portions and ciliate, appressed or with rather loose tips, the outermost subherbaceous and blackish green throughout, the others pale and multivittate below, with mostly longer blackish green tips, rays about 9, neutral, yellow, linear-elliptic, 9 to 12-nerved, 2 or 3-denticulate, pilose on tube and sparsely so on principal nerves of back, the tube 1.5 mm. long, the lamina about 15 mm. long, 3 to 4 mm. wide; disk corollas numerous, yellow with fuscous teeth, sparsely pilosulous on tube and back of teeth, 6 mm. long (tube 1 mm., throat cylindric, 4.3 mm., teeth triangular, acute, 0.7 mm.) pales acuminate, blackish above, sparsely pilose chiefly above, somewhat glandular on the sides, about 8 mm. long, infertile ovaries of the ray with a pappus of 2 or 3 lacerate squamellae 0.5 mm. long; disk achenes oblong, compressed, blackish, glabrous, 4 mm. long, 1.5 mm. wide; pappus of 2 caducous, lanceolate-acuminate, hispidulous-ciliate awns 3 mm. long.

Type in the herbarium of the Field Museum, no. 517591, collected in crevices of a vertical limestone cliff at Tarma, Dept. Junin, Peru, alt. about 3965 meters, June 1-6, 1922, by J. F. Macbride and W. Featherstone (no. 1070). Duplicate in U. S. National Herbarium, no. 1,198,869.

Readily distinguished from the other Andean species by its lanceolate, glabrescent leaves.

***Perymenium featherstonei* Blake, sp. nov.**

Shrub; branches strigillose; leaves lance-ovate, slender-petioled, acuminate, rounded at base, crenate-serrate, bullate and green above, densely griseo-tomentose beneath; heads small, slender-peduncled, in small cymes; involucre 5 mm. high, of broadly ovate, obtuse, strigillose phyllaries.

"Tree-shrub, 1.3 to 2.3 m. high, rather open but very erect," with opposite branches; stem subterete (3 to 6 mm. thick above), striatulate, lenticellate, glabrate, brownish or dark gray; internodes 1.5 to 6.5 cm. long; leaves opposite; petioles slender, naked, sulcate above, strigillose, appressed-pilose above, 5 to 12 mm. long; blades 5 to 8 cm. long, 1.5 to 3 cm. wide, crenate-serrate from above the short entire base to apex (teeth rounded, subequal, 4 to 5 per cm.), narrowly revolute-margined, subcoriaceous, above dull green, densely and harshly tuberculate-hispidulous with subappressed hairs, strongly bullate, beneath densely and rather softly griseously or cinereously pilose-tomentose except on the 3 chief nerves (these strigose), triplinerved 2 to 4 mm.

above base and reticulate, the veins and veinlets impressed above, the chief ones prominent beneath, the others mostly concealed by the tomentum; heads in cymes of 2 to 5 at tips of branches, subtended by reduced leaves, the pedicels angulate, strigillose, usually 1.5 to 4.5 cm. long; disk (in old fruit) subglobose, 6 to 7 mm. high, 7 to 9 mm. thick; involucre 3 to 4-seriate, graduate, 4 to 5.5 mm. high, appressed, the phyllaries broadly ovate or orbicular-ovate, obtuse, obscurely and shortly subherbaceous at apex, otherwise pale and indurated, strigillose and finely ciliolate; rays not seen; disk corollas (imperfect) about 3.2 mm. long, pales acutish to acuminate, narrow, strongly 1-ribbed, minutely hispidulous on keel, about 6 mm. long, ray achenes trigonous, hispidulous on angles and at apex, their pappus of 20 unequal, hispidulous, deciduous awns 1 to 1.8 mm. long; disk achenes obovoid-oblong, 2.5 to 3.2 mm. long, 1.5 mm. wide, biconvex, biauriculate at apex, narrowly whitish-margined, finely hispidulous especially on margin and at apex, fuscous, finely papillate, their pappus of 2 slender hispidulous awns 2.5 to 2.8 mm. long, on the angles, and about 12 similar shorter awns 1 mm. long or less, all deciduous.

Type in the herbarium of the Field Museum, no. 517839, collected in river canyon at Cabello, a hacienda 14.5 km. above Huertas, Dept. Junin, Peru, alt. 2440 meters, June 25, 1922, by J. F. Macbride and W. Featherstone (no. 1329) Duplicate in the U. S. National Herbarium, no. 1,198,875.

Allied to *Perymenium serratum* Blake, of the Province of Chachapoyas, which has a much larger involucre, 9 to 10 mm. high.

Pappobolus cinerascens Blake, sp. nov.

Branches slender, cinerascens-pilosulous and sparsely pilose; leaves lance-ovate, subentire, green and rough above, densely cinereous-pilose beneath; heads 2 or 3, terminal, medium-sized; involucre cinerascens-puberulous and somewhat pilose, graduate, of lance-ovate acuminate phyllaries with reflexed herbaceous tips.

Herb (?); branches slender (2 mm. thick), simple, subterete, striatulate, pithy, densely cinerascens-pilosulous with chiefly spreading or reflexed hairs and sparsely spreading-pilose; internodes 4.5 to 7 cm. long; leaves opposite throughout, or those subtending the peduncles alternate, petioles naked, densely spreading-pilosulous and long-pilose, 4 to 13 mm. long, blades lance-ovate or lanceolate, 6 to 8 cm. long, 1.7 to 2.5 cm. wide, acuminate, falcate, at base cuneate or rounded, entire or obscurely and remotely serrulate, very narrowly revolute-margined, above blackish green, densely and harshly hirsutulous and hirsute with curved hairs with persistent tuberculate bases, maculate in age, beneath densely and softly subtomentose-pilose with antrorse hairs, triplinerved 1 to 2 mm. above base, the chief veins usually impressed above, prominulous beneath; heads 4 to 4.5 cm. wide, in terminal cymes of 2 or 3, the peduncles slender, naked or with a single bract, pubescent like the stem, 2 to 8.5 cm. long; disk depressed-subglobose, 1.2 cm. high, 1.5 to 2.3 cm. wide (as pressed); involucre 4 to 5-seriate, graduate, 7 to 9 mm. high, the phyllaries lance-ovate or lanceolate (1.5 to 2.5 mm. wide), with blackish green, ribbed and vittate base and longer to shorter, reflexed, acuminate, somewhat involute, callous-tipped, herbaceous apex, densely cinereous-puberulous (inside and outside) on their exposed surface, tuberculate-hispidulous above, more or less pilose dorsally above, ciliolate; rays 14 or more, yellow, neutral, pilosulous on tube and nerves of back, the tube slender, 2 mm. long, the lamina elliptic, 2.4 cm. long, 6 mm. wide, 9-

nerved, 2-dentate; disk flowers very numerous, their corollas yellow, fuscous on teeth, puberulous on nerves of throat and on teeth, 6.7 mm. long (tube 1.5 mm., throat slender-funnelform, 4.2 mm., teeth ovate, 1 mm.); ray achenes (inane) with a caducous pappus of about 14 linear-lanceolate spinulose-serrulate unequal paleaceous awns 1.2 to 1.8 mm. long; disk achenes obovate-oblong, very strongly compressed, fuscous, glabrous, striatulate, 4 mm. long, 1.5 mm. wide, their pappus of about 16 caducous awns like those of the ray achenes, 1.8 to 2.8 mm. long, those on the angles the longest.

Type in the Kew Herbarium, collected in the Province of Chachapoyas, Peru, in 1836, by A. Mathews. Photograph and fragment of type in U. S. National Herbarium; duplicate in British Museum.

Allied to *Pappobolus mollicomus* Blake, also from Chachapoyas, with duplicate types of which (in Kew Herbarium and British Museum) it has been possible to compare it. In *P. mollicomus* the pubescence of stem and peduncles is much longer, being composed of long, spreading, tuberculate-based hairs, and the phyllaries are broader (3 to 4.5 mm. wide) and densely canescent-pilose, with longer spreading herbaceous tips. *Pappobolus macranthus* Blake, the type of the genus, is distinguished from the two other species by its usually broader, definitely serrate leaves, which are griseous rather than canescent or cinereous-pubescent beneath. It was described from Muña, Peru (wrongly "Bolivia" in the original description), and has been collected at Mito, Peru, 1922, by Macbride and Featherstone (no. 1384, a smaller-headed form than the original) and at Chaglia, Peru, 1923, by Macbride (no. 3646). All three localities are in the Department of Huánuco.

Oyedaea maculata Blake, sp. nov.

Shrub; branches densely scabrous-hispidulous; leaves oval or ovate-oval, acute, rounded at base, serrulate, very rough on both sides, triplinerved, short-petioled; heads medium-sized, 1 or 2 at tips of branches and in upper axils, short-peduncled; involucre 9 mm. high, of oblong, acuminate, herbaceous-tipped, scarcely spreading phyllaries.

Stem stout (5 mm. thick), striate, brownish, densely incurved- or appressed-hispidulous with tuberculate-based persistent hairs; internodes 5 to 20 mm. long; leaves opposite; petioles broad, densely tuberculate-hispidulous, 2 to 4 mm. long; blades 3.5 to 5 cm. long, 1.7 to 2.7 cm. wide, sparsely serrulate above the middle (teeth 3 to 5 pairs, 3 to 6 mm. apart), narrowly revolute-margined, firm and subcoriaceous, above brownish green, somewhat shining, evenly hispidulous with curved hairs with tuberculate or glandular-tuberculate persistent bases, beneath duller brownish green, evenly but not densely short-hispid on surface with spreading or slightly incurved hairs with small tuberculate bases, antrorse-hispid along the nerves, rather definitely triplinerved within 3 to 6 mm. of base (the lateral pair reaching slightly above middle of leaf) and with 6 to 8 other pairs of principal lateral nerves of which 1 or 2 are conspicuously stronger than the others, the nerves and veins unpressed above, prominent or prominulous beneath; peduncles 1-headed, solitary, terminal and in the upper axils, pubescent like the stem, 6 to 12 mm. long; heads 3.8 cm. wide or less; disk hemispheric, 1 to 1.3 cm. high, 1.2 to 1.5 cm. thick (as pressed); involucre 8 to 10 mm. high, 3-seriate, slightly or scarcely graduate, the phyllaries oblong (2 to 2.5 mm. wide), erect or with slightly spreading tips, acuminate, callous-tipped, the outermost herbaceous throughout, rather sparsely tuberculate and short-hispid, 1-nerved, the others with pale, indurate, more or less hispidulous-ciliate, otherwise nearly glabrous

base, and subequal, glandular-tuberculate, sparsely hispidulous and hispid herbaceous tips; rays about 11, yellow, neutral, hispidulous on tube and back, the tube 2 mm. long, the lamina oblong-elliptic, bidentate, up to 2 cm. long, 5 mm. wide, about 11-nerved; disk corollas yellow, essentially glabrous except for the finely hispidulous teeth, 7 mm. long (tube 2 mm., throat cylindrical-funnelform, 4.2 mm., teeth ovate, 0.8 mm.); pales acuminate, keeled, hispidulous on the slightly greenish apex, about 9 mm. long, disk achenes obovate-oblong, compressed, biconvex, 4.5 mm. long, 2.2 mm. wide, fuscous, 2-winged (wings thick, about 0.3 mm. wide, hispidulous on margin), very sparsely strigillose; awns 2, very unequal, hispidulous, 1.8 to 4 mm. long; squamellae acute, unequal, lacerate, united below, 0.8 mm. long or less.

Type in the U. S. National Herbarium, no. 1,230,911, collected on the subparamo, Cerro de Turumquire, Sucre, Venezuela, alt. 2975 meters, in 1925, by G. H. H. Tate (no. 232). Additional specimen, with the same data, collected under no. 233.

Related to *Oyedaea wedelioides* (Klatt) Blake, of Peru, and *O. jahnii* Blake, of the Province of Mérida, Venezuela. In the former the leaves are decidedly larger and borne on petioles 4 to 15 mm. long, the heads are several or numerous and cymose-panicled, and the phyllaries have spreading tips. In the latter the leaves are ovate or lance-ovate and much larger, and the heads are larger, solitary, and longer-peduncled.

Verbesina tatei Blake, sp. nov.

Section *Saubinetia*; stem stout, pithy, leafy, densely lanate-tomentose; leaves alternate, large, elliptic-oval, acute or acuminate at each end, repand-serrulate, stout-petioled, rough above, densely sordid-pilose beneath, heads medium-sized, yellow, radiate, many-flowered, numerous in a rounded terminal panicle; involucre about 8 mm. high, of oblong, obtuse, sordid-pilous phyllaries; rays about 5 mm. long.

Shrub or large herb; stem subterete, 8 mm. thick above, glabrate and yellowish brown below, densely lanate-tomentose above with dirty-white hairs; internodes about 1 cm. long; petioles 2 to 3 mm. thick, narrowly grooved beneath, densely lanate-tomentose, margined above the decurrent leaf base, the naked portion 2.5 to 3.5 cm. long; blades 12 to 20.5 cm. long, 4.5 to 8.5 cm. wide, thick-pergamentaceous, repand-serrulate above the entire cuneate base (teeth small, obtuse, 2 to 5 mm. apart), above dark green, evenly hirsutulous on surface with antrorse-curved hairs with small glandular-tuberculate persistent bases, hirsute-pilose along costa and chief veins, beneath brownish green, densely and rather softly ochroleucous-pilose on surface with curved hairs, very densely so on chief veins, feathervined, the chief lateral veins about 11 pairs, like the stout costa prominent beneath, the veinlets prominulous beneath, mostly impressed above, heads 1.8 cm. wide, about 32, on axillary and terminal peduncles, in a rounded panicle 11 cm. wide, about equaled by the leaves, the bracts small, the pedicels stout, 1.5 to 3 cm. long, densely sordid-pilose; disk subglobose, 1 cm. high, 1.3 cm. thick; involucre 3 to 4-seriate, graduate, 7 to 8 mm. high, appressed, the phyllaries oblong or the outermost ovate-oblong (1.5 to 3 mm. wide), obtuse, dark green, subherbaceous with (especially the inner) narrow pale margins, 1-nerved, sordid-pilous especially along costa and margin; rays 9 to 12, slightly exceeding disk, yellow, pistillate and bearing imperfect anthers, pilose on tube and nerves of back, 8.5 mm. long (including tube), 3 to 4 mm. wide; disk flowers about 75, their corollas yellow, pilose on tube and teeth

with several-celled acuminate hairs, glabrous on throat, 6 mm. long (tube 1.3 mm., throat subcylindric, 3.7 mm., teeth ovate, 1 mm.); pales pilose on the narrow keel and margin and on the yellowish, somewhat spreading or recurved, subscarious obtuse apex, about 7.5 mm. long; immature disk achenes obovate, compressed, scarcely winged, ciliate, sparsely pubescent above, 2.8 mm. long; awns, 2, subequal, stout, trigonous, hispidulous on keel, 4.5 mm. long.

Type in the U. S. National Herbarium, no. 1,230,946, collected on an exposed ridge, Cerro de Turumquire, Sucre, Venezuela, alt. 1830 meters, in 1925, by G. H. H. Tate (no. 350).

In pubescence, foliage, and inflorescence this species is strikingly like *Verbesina crassiramea* Blake of Colombia, a member of the Section *Lipactinia* with discoid, 5 to 14-flowered heads. Its closest ally, however, is the long-doubtful *V. humboldtii* Spreng. (*V. helianthoides* H. B. K., not Michx.) of Colombia. In the latter the stem is ascending-pilose to spreading-pilosulous, the internodes are longer, the petioles margined nearly to base, the leaves less densely and softly pubescent beneath, the heads much larger, the rays longer and apparently white, the phyllaries of the somewhat longer involucre distinctly broader, and the pales essentially glabrous (except for the more or less ciliate margin) on the thin acute or acuminate tip.

Verbesina humboldtii Spreng. was left among the doubtful species by Robinson and Greenman in their revision of the genus. It was described (as *V. helianthoides* H. B. K.) from "Regno Qutensi?" and is represented in the Paris Herbarium by at least two sheets of the original material. Hieronymus at first³ referred to it *Lehmann* 7481 from Colombia, but later⁴ described this as a new species, *V. lehmannii*, distinguishing it from *V. humboldtii* by several supposed differential characters derived from the original description of the latter. During the summer of 1925 I examined the type material of *V. helianthoides* H. B. K. at Paris and a specimen of *Lehmann* 7481 at Kew, and, through the courtesy of the curators of these herbaria, obtained photographs and small fragments of both specimens. Study of these shows that Hieronymus' species can not be maintained as distinct from *V. humboldtii*. *Triana* 1381, from Bogotá, alt. 2,300 meters, which I have on loan from the British Museum and the Kew Herbarium, belongs to the same species. The position of *V. humboldtii* is somewhat difficult to settle satisfactorily. So far as the size of the rays indicates, it might be placed as a small-flowered *Verbesinaria* (as was done by Hieronymus) or a large-flowered *Saubineta* (in the Paris specimens I recorded the rays as only 7 mm. long), but their white color would refer it rather to *Ochradinia* in Robinson and Greenman's treatment. One or two species of *Saubineta* (particularly *V. semidecurrrens* Kuntze, of which *V. soratae* Schultz Bip. is a synonym) are now known to have white rays, however, and the best position for *V. humboldtii* is probably in this group among the species numbered 68 to 79 in Robinson and Greenman's treatment, from all of which it is distinct.

In three heads of *Verbesina lateralis* examined the rays were all intermediate in form and structure between normal rays and disk corollas, being hermaphrodite and imperfectly ligulate. The short proper tube, at the apex of which are inserted the very unequal, nearly free, and non-polliniferous stamens, is continued into a funnel-form throat shorter than the proper lamina. The latter is equally or unequally 3-toothed, and sometimes bears a large

³ Bot. Jahrb. ENGLER 19: 54. 1894.

⁴ Bot. Jahrb. ENGLER 28: 612. 1901.

lateral lobe and a much smaller one, or the other two segments of the corolla are represented by two small and unsymmetrically placed teeth on one side of the apex of the throat. The style branches bear elongate hispidulous sterile appendages. Although the condition is doubtless abnormal, and not characteristic of the species, it is of interest as showing how easy is the transition from the tubular 5-toothed disk corolla, the theoretical type of the asteraceous corolla, to the 3-toothed pistillate ligule.

Verbesina oligactis Blake, sp. nov.

Section *Ochraetia*; tall; stem wingless, densely spreading-pilose with yellowish hairs; leaves alternate, large, oblong-elliptic, acuminate at each end, obscurely denticulate, tuberculate-pilosulous above, densely short-pilose beneath especially along the veins, short-petioled; heads small, very numerous, white, in a large terminal panicle, sessile or short-pedicelled; rays 1 or 2, disk flowers 11 to 13.

Tall herb (?); stem stout (6 mm. thick above), striate-angulate, pithy, densely spreading-pilose with yellowish-white hairs about 1 mm. long, internodes about 1 cm. long; petioles stout, densely pubescent like the stem, the unmarginated portion 3 to 5 mm. long; blades 20 to 25 cm long, 4 to 7 cm. wide, long-cuneate at base, remotely denticulate with small blunt callous teeth (0.3 mm. high, 3 to 8 mm. apart), papery, above dull green, evenly antrorse-pilosulous with yellowish-white hairs with glandular-tuberculate persistent bases, densely short-pilose along costa, beneath densely griseous- or flavescent-pilose along the chief veins with spreading several-celled hairs, less densely so on all the veins and veinlets, feathervined, the chief lateral veins 10 to 12 pairs, rather prominent beneath, the chief veinlets prominent; panicle terminal, flattish, very many-headed, 20 cm. wide, pubescent like the stem, the bracts small (mostly 3.5 cm. long or less), definitely serrulate with dark callous teeth, the pedicels usually 2 mm. long or less, sometimes up to 6 mm.; heads 6 to 8 mm. wide; disk obovoid, 4.5 to 6 mm. high, 3 to 4.5 mm. thick; involucre 2-seriate, unequal, 3 mm. high, the phyllaries few, lance-oblong or oblong (about 1 mm. wide), obtuse, appressed, thickened and subherbaceous at base, with longer, thinner, submembranous, pale tip, loosely and rather sparsely pilosulous and ciliate; rays 1 or 2, white, pistillate, the tube pilose, 1.5 mm. long, the lamina oblong, 4.8 mm. long, 2 mm. wide, nearly glabrous, 3-denticulate, 7-nerved; disk flowers 11 to 13, their corollas white, blackish green below the teeth, pilose on tube and throat, glabrous on teeth, 4 mm. long (tube 1 mm., throat cylindric-funnelform, 2.5 mm., teeth ovate, papillose-margined, 0.5 mm.), pales submembranous, blackish green with subscarios margins, pilosulous, ciliate above, subtruncate or with short blunt erect or slightly spreading glabrous apiculation, about 5 mm. long; disk achenes (immature) ciliate, pilose especially above, narrowly winged, 2.8 mm. long; awns 2, unequal, hispidulous, 2.2 to 2.7 mm. long.

Type in the Kew Herbarium, collected at San Miguel, Sierra Nevada of Santa Marta, Colombia, November 1844, by William Purdie. Photograph and fragments in U. S. National Herbarium.

A member of the *Verbesina punctata* group, nearest *V. synthes* Blake, also a Colombian species, which has thicker heads, containing 8 rays and about 29 disk flowers, borne on pedicels 7 to 14 mm. long. Similar also to *V. callacataensis* Hieron., of the Section *Lipactinia*, in which the heads sometimes bear as many as 3 very small rays. In that species the petioles are always auriculate at base, the heads are considerably larger, and the involucre is densely pubescent.

RADIOTELEGRAPHY.—*Preliminary note on proposed changes in the constants of the Austin-Cohen transmission formula.*¹ L. W. AUSTIN. Laboratory for special Radio Transmission Research. (Conducted jointly by the Bureau of Standards and the American Section of the International Union of Scientific Radio Telegraphy.)

It has been known for a number of years that the Austin-Cohen transmission formula, while satisfactory for moderate distances and wave lengths, gives values at 6000 km which are only about one-half of those observed, and that at 12000 km the ratio appears to be about one to four.

Our original formula² for daylight signals over salt water of 1910-1914, was written

$$E = 120 \pi \frac{hI}{\lambda d} \sqrt{\frac{\theta}{\sin \theta}} e^{-u} \text{ (volts km. amp.)}$$

where $u = \frac{0.0015d}{\lambda^{0.5}}$. The constants in u were determined empirically from shunted telephone observations for distances up to 2000 km and frequencies between 1000 kc ($\lambda = 300$ m) and 80 kc ($\lambda = 3750$ m).

Naturally I have been desirous of bringing the formula into better agreement with the observations. Acting on the advice of some of my European colleagues in the URSI, I have given up the idea of altering the Hertzian portion of the formula since this is the portion that rests on a theoretical basis, and have given attention only to possible changes in the values of the constants of the exponential term. These can easily be arranged so as to give excellent agreement for limited ranges of wave length and distance, but in order to give the formula a general character, it should be at least approximately accurate for all frequencies between $f = 1000$ kc ($\lambda = 300$ m) and 12 kc ($\lambda = 25000$ m).

During recent years a very considerable amount of experimental data on signal field strength has been collected. Long series of transatlantic observations have been taken by the American Telephone & Telegraph Company, The Radio Corporation of America, The Marconi

¹ Published by Permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

² Bureau of Standards Bulletin VII; 315. 1911. Reprint 159; and XI; 69. 1914. Reprint 226.

Company, the French Army at Meudon, near Paris, and the Bureau of Standards. The Marconi Company has also collected a vast amount of experimental reception data from various transmitting stations during the voyages of the S. S. Dorset from England to New Zealand (February and March, 1922) by way of the Panama Canal, and of the S. S. Boonah from Australia to England (June, July, August, 1923) through the Suez Canal. In addition, the Indian Post Office made field intensity measurements at Karachi, India, on several of the European high-power stations from November, 1921, to January, 1923.

All this material now makes it possible to determine the variations of field intensity with varying wave length and distance with some degree of certainty. The relative value of the different series of observations of course differs widely. Those in which the same stations are observed regularly over one or more years are naturally the most valuable. Those which have been taken during the voyages of ships, while important, may show large variations during different parts of the voyage, since in general only one observation is taken at any given distance from the transmitting station, and the results can at best represent the conditions during only limited portions of the year.

The use of much of the experimental material for deriving a formula which must by definition hold for an all water path is complicated by the fact that in most cases of long distance transmission the waves pass for a considerable distance over land. For example, the shortest great circle distance between Nauen, Germany, and Washington is roughly twenty-five per cent land, Rocky Point to London twenty per cent, Buenos Aires to Washington more than fifty per cent, while from Karachi, India, to the European transmitting stations nearly the whole path is over land.

The question of the relative land and water attenuation in radio transmission is not at all settled. It is generally agreed that for wave lengths below 5000 m, land attenuation is much greater than that over water, and it seems probable that there is considerable, though decreasing, land effect from 5000 m up to at least 15000 m. The amount of this effect naturally depends upon the character of the land traversed, and especially on conditions in the neighborhood of the transmitting and receiving stations. Observations at Washington covering more than two years indicate that signals from Bolinas, California, near San Francisco $f = 22.9$ kc ($\lambda = 13100$ m) have practically the same attenuation as over water, if the reported effective

height of the station is correct. On the other hand, a much more limited number of observations in Washington on San Diego, and in San Diego on the east coast stations indicate nearly twice the water attenuation. This may be due to local conditions near San Diego as this has always been thought by operators to be less favorable for radio work than San Francisco.

Notwithstanding these uncertainties, it has seemed worth while to make use of the accumulated data for obtaining at least tentative constants for a new formula. Up to the present a value of $u = 0.0014d$
 $\lambda^{0.6}$ seems to give fairly satisfactory results. This may be slightly varied as more and better observational data are obtained. Table 1

TABLE 1.—RATIO OF NEW AND OLD VALUES OF e^{-u}

λ km	d km					
	500	1000	2000	4000	6000	12000
0.3	0.93	0.86	0.72			
0.5	1.00	1.00	1.00			
1.0	1.05	1.11	1.22			
2.0	1.07	1.14	1.31			
3.0	1.07	1.15	1.33	1.77		
5.0			1.32	1.72	2.25	
10.0			1.31	1.62	2.09	4.40
16.0				1.55	1.94	3.75
24.0					1.80	3.25

gives the ratio of the new to the old values of e^{-u} at various wave lengths and distances, and Table 2 shows a collection of observed intensity values from various sources which are in good, or fairly good, agreement with those calculated according to the revised formula. The observations at Cliffwood and New Southgate³ were taken by the American Telephone and Telegraph Company and those at Karachi by the Indian Post Office.⁴

The series at San Diego⁵ was taken by the Bureau of Standards, while the Marion and Nauen observations on the S. S. Dorset and Boonah⁶ by the Marconi Company represent the averages taken from the observation curves of the two ships, one in March, 1922 and the other in July, 1923. Bordeaux changed its wave length from 23400 m to 19000 m, at about the time the Boonah sailed from Australia,

³ Bell System Technical Journal 4: 459. 1925.

⁴ London Elec. 91: 164. 1923.

⁵ This JOURNAL 15: 139, 1925.

⁶ Jour. I. E. E. (London) 63: 933. 1925

and this change resulted in such an increase in the efficiency of the station that the observations on the two ships could not be fairly compared.

TABLE 2.—SOME CALCULATED AND OBSERVED FIELD INTENSITIES

SENDING STATION	RECEIVING STATION	f kc	λ km	d km	E μ v/m		
					Calculated	Observed	
Nauen	Cliffwood, N. J	23 8	12 6	6350	44	42	1922-1923
Marion	New Southgate, Eng.	25 8	11 6	5280	40	53	1923-1924
Rome	Karachi, India	28 0	10 7	5230	24	20	} Nov, 1921, to Jan, 1923
Bordeaux	Karachi, India	12 8	23 4	5900	60	68	
Ste. Assise	Bureau of Stds.	20 6	14 5	6150	53	48	1923
Bordeaux	Bureau of Stds.	12 8	23 4	6160	67	71	1922
Buenos Aires	Bureau of Stds.	23 6	12.7	8300	30	37	1924
Cavite, P. I.	San Diego, Cal	19 3	15 5	11800	2 7	2 0	Aug 28-Sept 22, 1924
Marion	S. S. Dorset and Boonah	25 8	11 6	8000	11	12	} March, 1922, and July, 1923
				12000	2 7	3	
Nauen	S. S. Dorset and Boonah	23 8	12 6	8000	21	22	} March, 1922, and July, 1923
				12000	5 4	5 5	
Bordeaux	S. S. Dorset	12 8	23 4	8000	37	33	} March, 1922
				12000	13	10	

In a later paper the rest of the available data, both favorable and unfavorable to the formula, will be discussed.

SCIENTIFIC NOTES AND NEWS

On behalf of the American Geographical Society, presentations were made of the Culhum Geographical Medal to Dr. HARVEY C. HAYES, the Charles P. Daly Medal to Brig. Gen. DAVID L. BRAINARD at a joint meeting of the ACADEMY, Philosophical Society, and the Biological Society, on April 15.

Professor ERNEST COHEN, Director of the Vant' Hoff Laboratory, University of Utrecht, will address a joint meeting of the ACADEMY and several of its affiliated societies in the near future.

The following scientists will be in Washington; Dr. RUFUS L. GREEN, Professor of mathematics at Leland Stanford University, from April 24 to 30; Dr. WILLIAM MCPHERSON, professor of chemistry and dean of the graduate school of Ohio State University, from April 22 to 25; and Dr. E. L. NICHOLS of Ithaca, N. Y., from April 21 to May 16. All may be addressed at the Cosmos Club.

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

VOL. 16

MAY 4, 1926

No 9

SEISMOLOGY—*A symposium on earthquakes*¹

1 SEISMOLOGY—A RETROSPECT F A TONDORF, Seismological
Observatory, Georgetown University

Astronomers and geophysicists are generally agreed that the planetary mote on which mankind breathes and moves bespeaks an evolution of a nebulous mass, but the physics of this transmutation is a matter of very persistent dispute with them. Again they evaluate the time of this transformation into the hundreds of millions of years, but their bases of calculation are as diversified as the astounding figures arrived at. These are some of the uncertainties of geology, a science very pertinently christened by someone as the Benjamin. Undoubted, however, it does appear that from the very first incrustations of our globe, fretful apparently at its very existence, the earth gave way to expressions of this anxiety in repeated quiverings. The story then, of earthquake phenomena is undeniably very ancient. Once people began to tenant our sphere and reckoned time set itself to filing away for posterity items in the archives of the past, its computers were made aware that the flooring beneath their feet was running away from them. Rightly might we expect records to advise us when all of this first happened. Instinctively we turn to the inspired writings, but only to meet with much disappointment. True it is that there we find earthquakes referred to. This under two general connections. First they may be predicted in prophetic or apocalyptic literature, in which case it is not always certain whether the literal "earth quake" or simply some commotion (moral, social, or physical) is represented by the figure "earthquake." Secondly a few times earthquakes are mentioned as historical facts. Referred to without historical record,

¹ Papers presented at the 233d meeting of the Philosophical Society of Washington, March 6, 1926

or even certainly literal use of the word, we find the word "earthquake," in Hebrew *ra'ash*, in Isaiah, chapter 29, verse 6, and in Ezekiel, chapter 3, verses 12-13, chapter 37, verse 7, and chapter 38, verse 19. In the New Testament, where the word appears as "seismos," we find this in Matthew, chapter 24, verse 7, Mark, chapter 13, verse 8, and Luke, chapter 21, verse 11.

In the Apocalypse, or otherwise known Revelation of St. John the Divine, there are five mentions of the word, each prophetic and none certainly literal. As an historical record. In the Book of Kings we read "earthquake with fire," lightning is probably here referred to. Again in Amos, where the year is not determinable with any accuracy. It is unfortunate that the times in the Old Testament are so equivocal. As regards the earthquake at Horeb, witnessed by Elias and chronicled in the third book of Kings, the 19th chapter, the 12th verse, the passage reads "And after the earthquake a fire (usual word for lightning)." This took place in the reign of Achab, and, at least, three years after its inception. It is to be noted that the chronologies of the Kings differ by margins of fifty years or even more at the hands of various computers, but the more reliable date for the reign of Achab most probably reached from 873 to 854 B. C. This, therefore, is one of the oldest, if not the oldest scriptural record available in this connection. Others are chronicled to have taken place between the years 789 to 738 and 781 and 743.

It may not be uninteresting for me to mention in this connection that the earthquake accompanying the crucifixion and resurrection would have occurred in the spring (probably) of 28, 29, or 30 A. D. Again the earth shocks felt by the prisoners at Philippi may be assigned, with strong probability, to the year 51 A. D., though from late 50-52 A. D. would be the extreme margins. Before quitting this subject I feel obligated to mention the incident recorded in Numbers, chapter 16, verses 29-34. The engulfing of the rebels, as narrated here, by the fissure of the earth is not explicitly connected with any of the current expressions for "earthquakes" but, on the other hand, it need not have been of a supernatural character, and if not, it would be most likely referable to a local earthquake or accompanied thereby. In which case this quake would antedate the above. It is to be noted however that the date here would have to be read with a margin of at least a century and one half.

Little wonder, once a people were witness to one of these nerve-racking experiences, that they would make it the topic of their table talk. What they wanted to know was, what it all meant and particularly

curious were they to ascertain when it was likely to reoccur. So the wiser of the communities set themselves up as shock detectors, soon to realize that in the category of sensitive mechanisms, the human body is wholly unreliable. Man, as often as he recognized his shortcoming in the physical world, invoked the machine. Accordingly we read in the Chinese Annals: "In the first year of Yoka, 136 A.D., a Chinese, Choko by name, a smith by trade, hammered out of a lump

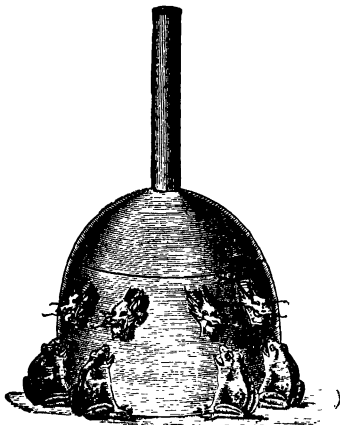


Fig 1 --First seismoscope, by Choko, 136, A D

of copper an instrument to which he or some one of his admirers gave the name of seismoscope (Fig. 1). The tale goes on to say: "Once upon a time a dragon dropped its ball without any earthquake having been observed, and the people, therefore, thought the instrument of no use, but after two or three days a notice came saying that a shock had taken place at Rosei. Hearing of this, those who doubted the use of the instrument began to believe in it again. After this ingenious

instrument had been invented, the Chinese government wisely appointed a secretary to make observations on earthquakes." Passing strange it is that in the history of scientific development there seems to have been a stagnation persisting from the very earliest findings till deep into the middle ages. Two striking instances are electricity and magnetism. Add to these investigations in earth shocks. For from the time of our Chinese friend till 1703 not one advance had been made instrumentally. Then it was that a French priest, De Haute Feuille, featured the first unimprovement (Fig. 2). Not only did he claim for his device a greater sensitivity than that of Choko, because

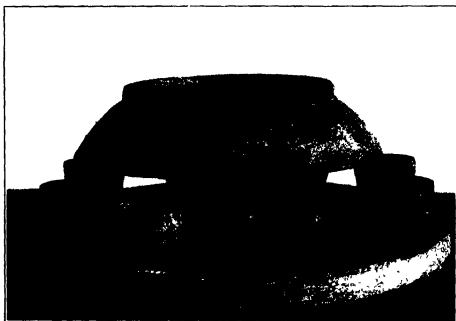


Fig. 2.—De Haute Feuille's modification of Choko's seismoscope, 1703

of the substitution of mercury for the metal spheres but also the additional asset of rating the intensity of the quake in terms of the displaced fluid.

It might be instructive to indicate all of the contraptions for recording tremors carrying us from what I might style the period of qualitative study of earthquakes into the quantitative, but time prevents. Close to the end of the last century a band of English geologists, amongst whom I may mention such names as Milne, Ewing, Perry, Knott, and Gray, made their way to Japan and there, in collaboration with the Japanese geophysicists, put together the first of the scientific

seismographs. Ewing is accredited with the first horizontal seismograph in 1879. The stationary mass of this machine was 25 kg and the length of the suspension 6.8 meters. Just one year later Gray announced his vertical instrument. Short functionings of these instruments early made it apparent that the earth's autographs were vitiated by a tendency of the swinging mass to take up its own natural period of oscillation, a condition which becomes very exaggerated where the period of the earthquake vibrations approximate that of the pendular mass. Wegener, an associate of Gray, first took notice of this. Gray very promptly attacked the problem of eliminating these vitiating elements and this through friction. Rood, an American geologist, first applied liquid damping. Toepler followed with air damping, a method quite popular even today. Galitzin's latest interference is magnetic. Possibly this is the most efficient. Brassart, in 1886, gave to science the first double component machine. This was of the heavy pendulum type. A very marked departure in earthquake instrument construction dates back to 1892 when Milne showed that a heavy mass is not an essential feature of an efficient seismometer. In 1894, on the suggestion of the same Milne, the photographic sheet became a close competitor of the sooted parchment. Galitzin's magnetic registration and Wood-Anderson's torsion pendulum close the story of the earthquake instruments to date.

Investigations into the transmission of earth movements through the earth's capsule were first launched by Young. His was the mind that suggested that the propagation was akin to that of sound waves in air. Gay-Lussac concurred. In 1846 Mallet first put the transverse waves into competition, though he by no means made it clear that two types of undulations were distinct, to wit the longitudinal and transversal, or compressional and distortional. This was reserved for Wertheim. Milne, following his instrumental findings, placed a definite imprimatur on these interpretations. Wiechert, in 1899, first read out of grams the reflected longitudinal wave and Zoeppritz first the transversal waves once reflected. Wiechert seems to have first diagnosed the long or Raleigh waves which many years antecedently Ewing had mistaken for the transversal. Seismologists have not as yet bequeathed us all the wealth of the gram.

Following the complete identification of these elastic undulations, the seismologist, knowing what he was after, had to establish their running record. To Wiechert and Zoeppritz credit is due for the first reliable time curves, reading up to 12,000 kilometers, though earlier attempts at these had been made by Schmidt, Milne, Benndorf, and

Oldham. In 1912 Wegener edited charts for distances in excess of 11,000 kilometers. Others followed in quick succession. These by Gutenberg, Meisner, Mohorovicic and Angenheister. There is still a readiness on the part of geophysicists to accept even more reliable tables. One might suspect that attempts at fixing the exact centers of quakes were very early. Far from it. Mallet appears to have been the first to establish the geography of these happenings from iso-seismal lines. Where reliable observers are available, this method still qualifies. No further back than 1911 did Milne work out his first group of epicenters covering quakes between the years 1890-1903, on the basis of triangulation. A second group appeared in 1912 spanning the years 1904-1909. The work then fell to the lot of Turner who published centers for 1911 and 1912. Strassburg pledged itself to the work in 1918 but due to the world war the results are now some four years in arrears.

Every people seem to have had a secret formula for solving the problem of earthquake occurrences. One or other may be mentioned. The ancient Greeks held resentful Zeus responsible for these visitations. The Babylonians attempted to read their wherefore in the stars. The inhabitants of the West Carolinian Islands fancied they heard in them the stampeding of giant animals against the earth's crust. Others deciphered them as the rappings of warning spooks. Over against these unique, not to say, grotesque ravings, we have the more reserved interpretations of the older philosophers. Pythagoras, 580 B.C., attributed earthquakes to underground fires therein anticipating volcanic earthquake history. Metrodorus, a pupil of Democritus, 460 B.C., made a guess at a theory which pressed hard in on the prevailing theory of today. He said: One mass of the earth may sink, following gravity, while another has to rise to maintain equilibration. Epicurus, 341 B.C., favored the notion, afterwards sponsored by Germans, that the ground water dissolved out certain geological materials and that the overhanging dome, for want of support, collapsed. Aristotle, 384 B.C., conceived earth tremors to be brought about by the attempted escape of air imprisoned within subterranean cavities. Cardano, mathematician and philosopher, about the middle of the 16th century, looking on the earth's interior as one gigantic crucible, saw therein sulphur, bitumen, and saltpeter chemically interacting and the energy liberated causing havoc to the abutting walls of the laboratory. Alexander von Humbolt orthodoxly observed that though there were earthquakes usually connected with volcanic eruptions, such were distinctly in the minority as compared with the

devastating quakes of history. He conceived, therefore, the volcanoes to be safety-valves for the pent-up gases imprisoned within the earth. A return here to the Aristotelian doctrine. Here I must mention Mallet, an English inventor of machines of war. When in 1857 a destructive quake razed the kingdom of Naples, he applied to the Royal Society for a grant for research along this quake. As he was deemed qualified for such studies because of his familiarity with explosives, the allotment was made with the result that the bookshelves of the seismologists were graced with two new volumes, entitled "The Neapolitan Earthquake." This in 1857. Mallet, so we read in these tomes, agreeing with Aristotle on the fundamentals of his theory, applied thereto the findings of the Dutch physicist, Huygens, on the travel of harmonic disturbances in different media. With these embellishments Mallet christens the theory the centrum theory. For the first time, too, we meet with the terms, now bywords with the seismologists, centrum, epicenter. About fifty years was to be its lifetime. The great quake in the Neo Valley, Japan, 1890, set geologists to doubting it. Photographs taken of the territory showing macroseismal movements indicated fractures running for miles across the country and that along these seams of rupture the land had seesawed, rising in one point to a maximum height of eight feet, while in some places, though neither side had been raised or lowered in reference to the other, the two sides had slipped by each other in opposite directions. Six years following this catastrophe there occurred the heavy quake in Assam. Three fractures were located in a study of a restricted portion of the affected area and a vertical displacement of thirty-five feet. Oldham published a memoir in which he contended that one plane of fracture was clearly a thrust on a plane of low angle to the horizon. In 1906 Tarr and Martin contributed an article to the Bulletin of the Geological Society of American in which they showed that following the severe quake of September, 1899 in Yukutat Bay, there were marked depressions in the coast line and elevations on land amounting to 16 meters. This they attributed to mountain growth with vertical adjustments between the large blocks within a fault mosaic. In 1907 Mr. Willard Johnson made a field survey of the Owens Valley quake of 1872 and for the first time an accurate map was prepared of a fault network suffering adjustment at the time of earth movements. With such imprimaturs the so-called tectonic theory of earthquake has grown until today it is a dogma of the seismic school.

The researches of the past half century and particularly of the past decade have dowered seismology with a wealth of information. These

investigations have been stimulated through such agencies as the British Association Seismology Committee, the International Seismological Society, with headquarters in Strassburg, the Imperial Earthquake Investigations Committee, Tokio, Japan, the Seismological Society of America, and the Carnegie Institution of Washington. Besides, the several governments the world over have lent most liberal encouragement to this work. Most recently have our own United States officially authorized seismological researches and designated the Coast and Geodetic Survey to execute them. The authorities have so auspiciously inaugurated this new activity that it is quite apparent that our country in the very near future will add many more interesting pages to the history of this most important of the sciences.

2. OUTSTANDING PROBLEMS IN SEISMOLOGY. N. H. HECK, U. S. Coast and Geodetic Survey.

The outstanding problem in seismology is to develop a future worthy of the past. There might appear to be no reason to feel any doubt, and yet such a future will not be assured without special effort. A few days ago I read a review of the art conditions in various countries which was rather critical of present conditions. The critic overlooked the fact that probably many of the men who would have been the outstanding or arriving artists now were killed or wounded in the war. The same thing would appear to apply to seismologists especially in the countries which were most active before the war.

I do not intend to discuss details but only the outstanding points in the various problems which are now occupying the attention of seismologists. Each subject could be the basis for several papers.

An apparently simple problem is one which many seismologists have given up in despair and yet which apparently cannot be dispensed with,—the determination of isoseismal lines through appraisal of intensity by observers. This, of course, applies only to earthquakes whose effects are felt or visible.

The elements of the problem include: inability of the average man to tell his experiences accurately, especially when disturbed; difficulty in securing proper distribution of competent observers; actual changes in effects from place to place, as between rock and alluvial land; disagreement between two observers at the same place; and difficulties in adopting a scale of intensity which will fit all the observations.

The solution is necessary, as in most cases there is no other practical means for determining the area disturbed and distribution of the in-

tensity. At present the effort is to get the largest possible number of competent persons to report; the Coast and Geodetic Survey has adopted a form which guides the reply, but which leaves it free for the observer to state his own impressions. He is not asked to estimate the intensity. It has been proposed to form special local organizations in earthquake regions for the purpose of making accurate reports. The Weather Bureau has taken an active part in this work in the past, and is continuing to do so. With the best possible results, the problem is much like that of plotting magnetic lines for a region of magnetic disturbance, though with good judgment reasonably satisfactory results are obtainable.

It has been made clear that instrumental development is the necessary background. Adoption of good instruments in this country is most important. The Wood-Anderson seismometer seems to give considerable promise as a teleseismic instrument, and the test now being made under observatory conditions at the Coast and Geodetic magnetic observatory at Tucson, Arizona, is likely to be productive of much benefit.

Most of you have had occasion to use apparatus in which an essential feature is the uniform rotation of a cylinder. This was not well accomplished in many of the best European types of instruments. The need for such apparatus developed during the war and it is now possible to have rotation of any desired accuracy. The problem is now to secure the result with minimum cost and minimum complication of apparatus. It will be seen that this matter of accurate time is vital to many parts of the study. As soon as an entirely satisfactory apparatus of low cost is developed for the Wood-Anderson instrument, it is going to be possible to have widespread distribution of good seismographs.

One of the outstanding needs is the operation of vertical instruments. Such records are indispensable, but at present there is no suitable instrument which can be operated with a moderate degree of attention. Father Tondorf is making a wonderful contribution at Georgetown University by operating his Galitzin vertical, but he will admit that it is a difficult instrument to install, operate and keep in order. Until we have more vertical instruments, certain urgently needed studies must be postponed.

Assume that we have satisfactory instruments, what are we going to get out of them? The results that we are going to get depend both on ability to interpret the seismogram and to completely develop the underlying theory. A great deal of work has been done on both of

these problems during the present century. Just as in every field of science, as the significance of various phases has been established on apparently good evidence, there have been some who have refused to accept the conclusions and have forced the accumulation of evidence till it was overwhelming. This is a proper course, though in every case the critics should be those who are themselves making contributions to seismology.

The *P* and *S* waves are now generally accepted as having definite significance, but Wiechert, as recently as 1903, had difficulty in securing the acceptance of the *S* wave as a transverse wave following nearly, if not quite the same path as the longitudinal *P* wave. It took much study to develop and recognize the various reflected waves and this process is still going on. The complications of the subject can be readily recognized when it is considered that at each reflecting surface there are really five possibilities, in case the approaching wave strikes the surface obliquely, though all of them do not occur in every case.

Suppose the incident wave is longitudinal. There may then be a reflected longitudinal and a reflected transverse, each taking a different path; also a transmitted longitudinal and transverse, each taking a different path. There will also be Rayleigh waves transmitted along the surface. Though ordinarily in the case of the surface, not more than three reflections have been recognized, the possible number of reflected waves is very great and certain series may appear under some conditions and another set under others. It is evident that this is a problem worthy of the best efforts of seismologists. Though it is far from being fully solved, it is significant of the new spirit in this country that Dr. James B. Macelwane, head of the Jesuit Seismological Association, is at present engaged in preparing tables which extend the work of Klotz, Visser, Gutenberg and others so that we may take into account a large number of phases. He is preparing convenient tables to make this possible. The method is to determine the approximate distance of epicenter, then enter the tables and take out the time of arrival of the phases given. Then make an independent study of the seismogram and set down the phases observed. There should, with good records, be an agreement of perhaps eighty per cent of the phases when the correct distance has been adopted. This makes it possible to obtain much greater distances accurately than the previous tables permitted. The unidentified twenty per cent of the phases may be either non-existent or not yet identified. This shows the need for further investigation.

The tables cover average conditions. At some stations average

conditions do not give good agreement. This seems to be unquestionably true of the records obtained at the Honolulu Magnetic observatory. An investigation is in progress to establish this fact beyond argument and discuss possible explanations. In general, waves reach this station considerably in advance of the time required by any existing theory.

Long waves, though the most impressive parts of the seismogram, are less important for obtaining distance than for determining intensity. They are extremely complex and have only in part responded to mathematical treatment. A mathematical physicist has an ample field for his effort.

To obtain the intensity of the ground movement, it is necessary to obtain from the seismogram the acceleration and the intensity. Determination of the acceleration, which is the factor needed by designers of structures and which may be also used in placing isoseismal lines, is an essential operation. The acceleration can be obtained from the period and the amplitude. With well-designed seismographs the period of the recorded wave is practically equal to that of the earth wave, but the instrument, for practical reasons, is designed to give a much greater amplitude than that of the earth's movement. The magnification is calculated from the period of the earth wave and instrumental constants, and the amplitude of the earth movement may thus be known. With an undamped seismograph magnification cannot be determined when the period is the same or nearly the same as the natural period of the instrument on account of resonance. This is a frequent occurrence in the case of the long wave.

The theory of wave transmission has been investigated mathematically in quite a thorough manner but parts, even of the generally accepted theories, do not satisfy all seismologists and there is a vast amount of debatable ground for future investigation.

A knowledge of the direction of the earth vibrations (in three dimensions) is necessary to determine depth of focus. The problem of maximum depth of focus, as well as depth of a given earthquake, is naturally one of great interest.

The establishment of isostasy would seem to make it necessary that all earthquakes should occur above the depth of compensation. Geodesists are therefore interested in more accurate determinations of depth of focus. This will require more accurate timing of arrival of phases than heretofore and the recording apparatus developed by Wood and Anderson will help to solve this problem. The stations now being established by the Carnegie Institution in California should

give valuable evidence on this question of depth, the only possible difficulty being that most of the earthquakes there are probably relatively shallow, as evidenced by the effect on the surface of the earth.

Certain phases appear on seismograms which can be explained only on the assumption that there are reflecting layers at the depth of 60 kilometers and 2900 kilometers, respectively. These layers are established beyond a doubt and there is good evidence for other such layers. The 2900 kilometer layer is also arrived at by other methods, such as those used in the studies of the Geophysical Laboratory. The physical significance of these surfaces of discontinuity afford an interesting problem in physics.

The phenomenon of crustal creep seems to be established for regions such as California where earthquakes are known to be of not infrequent occurrence. The measurement of the amount of change of positions both horizontally and vertically by geodetic methods has now been carried to the point where the determination of the manner in which strains develop and are released may be possible.

The Coast and Geodetic Survey is, by the nature of its other work, especially attracted to consideration of the submarine earthquake. Its accurate surveys along our coasts are going to make it possible to determine accurately the changes due to earthquakes. An important illustration of this has been recently found in investigation of the records. In 1914 an accurate survey was made by modern methods of a shoal near the Cuyo Islands, Sulu Sea, Philippine Islands. Eighteen months later it was found that part of the shoal had dropped through at least 100 feet. An earthquake was recorded about halfway between the two surveys. This is probably the only case where change has been proved by comparison of two modern hydrographic surveys, each of the same standard and with control of positions by high-grade triangulation determination of the objects used. The details of this case are of more interest to geologists, but there is a definite relation between such cases and the broad questions of geophysics.

I have left a number of important problems unmentioned, but believe that I have described enough of the problems to show the great field of investigation that is open to the seismologist, which will not only be of scientific value but will have a direct bearing on the solution of some very practical problems of preservation of life and property.

3. EARTHQUAKES FROM THE ISOSTATIC VIEWPOINT. WILLIAM BOWIE, U. S. Coast and Geodetic Survey.

In attacking problems relating to the structure of the earth's crust and the processes which change surface features, it is desirable that all available data be used. One of the earth problems awaiting solution which is receiving a great deal of attention to-day is the earthquake. The data resulting from the isostatic investigations should prove of value in studying this phenomenon.

It is not possible, in this short paper, to cover the subject of isostasy. What is known of that condition of the earth's crust is set forth in many reports and papers, readily available, which have appeared in recent years. Here we need merely accept isostasy as a scientific principle and see what is its probable relation to those processes which are at work within the earth to rupture rock and cause the tremors known as earthquakes.

The isostatic investigations seem to indicate very clearly that the depth to which the isostatic compensation extends is about 60 miles below sea level. That depth is not a fixed one, always the same in different places. The derived depth of 60 miles from geodetic data is an average one. The compensation, in some places, may extend to a greater depth and at others may not reach so deep below the outer surface of the earth.

It has been shown, with some degree of exactness, that the compensation of topographic features is a somewhat local phenomenon, but it is uncertain as to whether or not the compensation extends horizontally 25, 50, or some other number of miles from the feature. A test of whether or not strictly local or regionally distributed compensation most nearly eliminates the isostatic anomalies was reported on in Special Publication No. 10 of the U. S. Coast and Geodetic Survey. Regional distribution, out to a distance of about 37 miles from topographic features, eliminated the anomalies about as well as strictly local compensation. When the compensation was distributed regionally to a distance of about 104 miles from the topographic feature, the anomalies were larger, on an average, than for the other methods of distribution.

A test was made to show the mass of a topographic feature which might escape isostatic adjustment.¹ The results seem to indicate that any topographic feature, having an average thickness of 3000 feet and a radius of about 18 miles is, at least largely, compensated.

¹ See p. 34, Special Publication No. 99, U. S. Coast and Geodetic Survey.

The crust below all classes of topography, whether high, low or intermediate in elevation, is in isostatic equilibrium. This is true for the various geological formations, whether old, recent or intermediate. The isostatic test has been made for a number of regions; these include the whole of the United States, southern Canada, the Mackenzie River Valley in Canada, Holland, western Siberia, the Alps, India, the Solomon Islands and their vicinity, and Spain. In every case the crust beneath the geodetic stations used has been found to be closely in equilibrium. We are justified I think from the results of these tests in predicting that tests in other regions will show that the crust beneath them is also in isostatic equilibrium.

All mountain systems existing to-day occupy areas which previous to the uplifts were areas of heavy sedimentation. How can an area that was once low, subjected to 10,000 feet or more of sediments and, presumably, in isostatic equilibrium (for all sedimentary areas to-day are in that condition) become an area of uplift, with an average height of topography of a mile or more, with the crust below still in isostatic equilibrium? The mountain mass is not an extra load on the subcrustal base beneath the mountain area. If it were so, surely this condition would be detected by the deflections of the vertical and the values of gravity at stations in the vicinity of the mountains.

There are two ways in which a mountain system can be formed in a sedimentary area and still not have the mass as an extra load. One is to have the crust of the earth thicken beneath the mountain area with roots projecting into subcrustal space. These roots would just balance, by their deficiency in density, the mass that forms above sea level. This is what is called the "roots of mountains theory," advanced by Osmond Fisher a number of years ago. Fisher was following the equilibrium ideas of Airy.

The second method would be to have a decrease in the density of the crustal material beneath the sediments, resulting in an increase in the volume. The material would tend to expand in all directions but it could not go down nor would it be able to push sideways to any extent. The line of least resistance would be upward and this is the direction in which the material goes. This latter theory is based on the idea of Pratt.

One of these theories must be true, but which one no one knows. But the indications seem to be that the Pratt idea is much the stronger of the two. The "roots of mountains" theory has a number of weak points which have not been cleared away by its advocates. I strongly advocate the Pratt idea and the statements made in this paper are based on it.

We seem to be left, then, with the earth's crust, approximately 60 miles in thickness, in almost perfect isostatic equilibrium. The topographic features are compensated by deficiencies or excesses of density in the crustal material in the vicinity of the features. This compensation may extend horizontally to a distance of 20, 30, or possibly some greater number of miles, from the feature, but it is probable that the regional distribution of density does not extend out as far as 100 miles from a topographic feature. A topographic feature, having dimensions equivalent to 3000 feet in average thickness, with a radius of 18 miles is at least largely compensated. The mountain systems occupy areas which in a previous period had been subjected to heavy sedimentation. Those areas of heavy sedimentation were along the margins of oceans or of inland seas.

We have, in the above, information and data of great importance in the study of earthquakes but we have additional information which must be considered. This is that the isostatic condition of the earth's crust is probably maintained while tremendous loads of material are shifted over the earth's surface. The rate of erosion in the United States is such that one foot, on the average, would be denuded from the 3,000,000 square miles of our area in 9000 years. This is a rate of half a mile of erosion in 20,000,000 or 30,000,000 years. The average elevation of the United States is about 2500 feet and at the above rate most of this mass would be denuded in a comparatively short time. But we must remember that, as erosion takes place, the isostatic equilibrium is not permanently disturbed. If 1000 feet of material were eroded from an area, undoubtedly the original crust below would be lighter than it had been before, but the pendulums and deflection of the vertical stations do not show that an area of rapid erosion is out of equilibrium. We must conclude that, as the material is eroded from the surface, there is a transfer of subcrustal material into the crustal space to offset the erosion. We do not know the density of the subcrustal material but it is reasonable to assume that it is 10 per cent or more denser than the surface material which is approximately 2.7. In any event, in order to base-level an area, it would be necessary to erode from it several times as much material as appeared in the original mountain mass. Under the influence of erosion, the crustal material below is brought into higher and, presumably, colder regions. This coming up of the crust undoubtedly results in fractures in the crustal materials and especially in the cold rock near the surface, thus causing earthquakes. It is probable that this process was involved in the earthquake in Montana during the summer of 1925.

As material is laid down along the margins of an ocean or an inland sea, the crust below sinks under the added weight, but it would appear that only a moderate amount of sediments could be laid down in shallow water in any particular region because of differences in density of the sedimentary material and the subcrustal material. It is probable that the subcrustal material is at least 20 per cent denser than the unconsolidated sediments. We have, however, evidence of many thousands of feet of sediments having been laid down in shallow water. We must, therefore, conclude that there is a sinking of the crustal material, independent of the weight of sediments.

An analysis of the situation leads us to believe that this independent sinking is due to cooling off of the crustal material which was uplifted during a prior period of erosion. As was mentioned earlier, the crustal material below an erosion area rises to colder regions. Eventually that material will cool down to the temperature normal to those new places; then some physical or chemical reaction probably takes place which contracts the crustal material which had been uplifted. A sinking of the surface would take place, due to this contraction, and a synclorium would be formed into which sediments are deposited. Does it not appear, therefore, that any area that is receiving or has received great masses of sediment all laid down in shallow waters, was previously a mountain area, or at least one of high elevation, from which much material had been eroded?

As the material of the crust which had been carried upward during erosion contracts, the contraction would tend to take place in all directions. This would probably make rifts within the contracting material and between that material and the unaffected crust to the sides, but the crustal material is not strong enough to maintain a rift extending to a great depth (what depth we do not know). It would appear, therefore, that there would be a horizontal movement to fill any deep rifts that might have opened. It would seem probable that there would be some slow movement of material, resulting in distortion without fracture, but it seems logical to assume that some of the contraction would result in rifting and that this would give rise to earthquakes. As the sediments are laid down on the crust the weight of this added material will push down the crustal material beneath it. This will force aside subcrustal material equal in mass to the added weight. In addition to the earthquakes due to independent sinking, it would seem to be most probable that earthquakes in sedimentary areas are also caused by the weight of sediments pressing the crust down. Some of the pressing down from the weight of the sediments

will take place so slowly that the crustal material will yield to the stresses without fracture. At times, however, the sediments will accumulate more rapidly than the ability of the crust to assume new shapes and forms without rupture or crushing. In these cases the material will be strained beyond the elastic limit and a break will occur, causing an earthquake. It is probable that about one-fifth of the lowering of the base of the sediments is due to the contraction of the crust below, and four-fifths to the sinking caused by the weight of the sediments.

As the sediments are laid down along the margins of an ocean or an inland sea and the crust sinks beneath, the crustal material will be carried down into hotter regions. The sediments in some cases are as much as five or more miles in thickness and it is reasonable to suppose that the crustal material beneath these sediments will be carried down approximately an equal amount. When the material assumes the temperature of its new position, there will be a chemical or physical reaction, or a combination of the two, which will expand the crustal material. There will also be the ordinary thermal expansion. It is possible that the mountains and plateaus are formed by the expansion of the crustal material below them. In fact, it is most probable that this is true if the Pratt equilibrium idea is the correct one.

In the process of uplift to form the mountain system, cubical expansion would tend to operate, but the material cannot go down nor sidewise, therefore the movement is upward. There would be much crushing of material during upward movement and in the confining of the movement to a single direction. Much of the distortion of strata and the horizontal displacement as observed in an uplifted area may be merely incidents to the vertical movement. In any event this expansion of material to cause mountains or plateaus will undoubtedly rupture rock near the surface and give us earthquakes.

There are other earthquakes than those mentioned above. These are caused by the explosions occurring in the vicinity of volcanoes. These earthquakes, as a rule, are not very heavy ones.

With isostasy established as a scientific principle, we are forced to conclude that the subcrustal material is plastic to long continued stresses or, at least, that it has very low residual rigidity. It would therefore seem to be most probable that the subcrustal material would yield without fracture to the stresses resulting from shifting of loads on the earth's surface. This leads us to believe that the earthquake must be a phenomenon confined to crustal material. Since the crust is approximately 60 miles in thickness, we should not expect the epi-

centers of earthquakes to be at a greater depth than 60 miles below sea level. The late Prof. Omori, the famous seismologist of Japan, made a statement in one of his papers that he had not located any epicenters at a greater depth than about 27 kilometers. This fits in with the isostatic principle. The determination of depths of epicenters is a subject which is receiving a great deal of attention by seismologists and we shall look forward with interest to the results obtained by their studies.

Conclusions: Based on what has been said above, we must postulate that we have several causes of earthquakes. Since the theory of isostasy has been proved and may now be called the principle of isostasy, we must not ignore the equilibrium of the earth's crust in earthquake studies. It seems probable that the isostatic equilibrium of the crust has obtained throughout the sedimentary age of the earth. Earthquakes are, apparently, due (on the isostatic principle) to the maintenance of isostatic equilibrium during erosion and sedimentation, the expansion of the crustal material which has been thrust downward under sedimentation into hotter spaces, and the contraction of the crustal material which has been pushed upward into colder spaces under areas of erosion. These would appear to be the major causes of earthquakes. In addition, there are the volcanic earthquakes of more or less local character and of minor importance.

4. DIFFICULTIES IN THE STUDY OF LOCAL EARTH MOVEMENTS. ARTHUR L. DAY, Geophysical Laboratory.

In 1905 I was sent officially to England to confer with Sir John Milne in regard to some contemplated developments in the study of earth movements, and visited him at that time at his place at Shide on the Isle of Wight, where he had a number of seismographs set up and operating. He was then of course nearing the close of his career.

Milne, at that time, was a gentleman farmer by environment, and had become the world's foremost student of seismology through the pursuit of his chief avocation. He intimated that it was a gentleman's privilege to choose his pleasures as he wished, and this was his choice. I was shown his equipment with much enthusiasm. Without explanatory preface he told me then and there the cause of two-thirds of the recorded earthquakes, namely, spiders in the instrument case.

A little later Mr. Gutenberg, who stands in the very front rank of seismologists today, was able to explain a portion of the remaining ones. It appears that in the great laboratory at Göttingen which has become

familiar to you all through the work of Wiechert, earthquakes were at one time of frequent occurrence whenever a certain outside window was open. They did not persist when it was closed.

Notwithstanding these historic episodes, or perhaps occasionally because of them, the study of earthquakes is a thoroughly serious business, as all of those distinguished men who have sought to approach the subject quantitatively have discovered, whether the search be directed to the causes of local earthquakes or to the constitution of the earth's interior mass.

It is quite possible by the use of these refined methods, which have been described to you so clearly by Father Tondorf, to pick up earth vibrations of many different vibration periods beginning as low as from four to seven or eight-tenths of a second. These short waves form a class by themselves, which was first seriously studied by the Göttingen group and originally ascribed by them to the waves of the North Sea. One early difficulty lay in the fact that the direction in which the sea lay was not always the direction from which these waves had come according to the seismograph record. Afterward Gutenberg became interested, as most of you know, to try to fix upon some other natural phenomenon which might prove adequate to explain these short-wave disturbances. He studied the relation between the movements indicated by his instruments and the beating of the waves upon the rock-bound coast of Norway, the varying barometric pressure, the wind-velocity of the storms which visited the region, and finally with different varieties of traffic at various distances. In general these discussions, which came out some ten years ago and were very generally participated in by the seismologists at work at that time, established the fact that probably all of these causes have some share in the so-called short group of waves, but the actual share of each of them was not then and is not now established. It is probably true that the waves of the sea had some share in these short-wave disturbances because the instruments set up on the Island of Helgoland in the North Sea plainly show such impulses of appropriate period. There has also been for many years a very well-equipped laboratory upon one of the Islands of the Samoan group where earth movements of period appropriate to the sea waves have been recorded. Nevertheless the matter is not cleared up and disturbing movements of unknown origin still pursue the student of short-period earth movements, i.e., of local earthquakes.

In California we have on the west coast a mountain range (the Coast Range) which geologically is quite unstable, and has been

likened by Lawson to a door which rises and falls on a hinge (the Sierra Nevada mountains); which has swung below the sea at least a mile and above the sea by an amount equal to its present elevation, five or six different times in the course of its geologic history, as is evidenced by alternate depositions of marine sediments and the sand and clay accumulations from surface erosion. Out of the geologic history of the region therefore we know that tectonic forces have lately been and probably still are locally active,—this is one of the chief reasons why the Carnegie Institution has selected it for the earthquake studies now in progress there. It is not a region like a volcanic centre in which occur only local earthquakes which are felt but a short distance away, but it is a region of frequent and powerful local movement. The epicenter of the 1906 earthquake extended over 190 miles of land, and probably more of ocean floor, as you undoubtedly recall. Likewise the Santa Barbara earthquake of the past summer, though local in point of damage to buildings, was complicated and possibly far reaching in its effect upon geologic structures. Its source has been traced to two faults, one of which is perpendicular, at the base of the Santa Ynez Mountains, the other is a thrust fault from the direction of the sea. The two intersected at a comparatively narrow angle within which stood the more thickly settled portion of the city of Santa Barbara. Both active faults have been located by investigation since the earthquake. We are therefore confronting here local tectonic movements of considerable severity and complication and may expect others.

There is one other limitation which confronts the student of local earth movements which is neither attributable to spiders nor to air draughts, to sea waves nor to storms, there are great differences in the kind of crustal movement recorded, which vary with the sort of foundation the instrument happens to be standing on. The most convincing illustration of it is to be found in the fact that the greatest destruction always occurs on filled land. Reid has developed a theory of the movement of masses of alluvium contained in a rigid bowl to which forces are applied from without. It is contained in the second volume of the Report of the California Earthquake Commission published by the Carnegie Institution of Washington in 1908. In illustration of this Professor Rogers of Stanford University, during his study of the 1906 earthquake, built a box a meter or more long and half as wide, filled it with wet sand and attached it by a horizontal crank shaft to a wheel, so as to be shaken to and fro with a measured period and amplitude, in order to see what relation the movement of the sand might

bear to the movement of the box containing it.¹ This relative movement is best shown by Rogers' curves, reproduced in Fig. 1, but the amplitude of movement of the sand was always greater than that of the containing vessel, usually about twice as great, and was relatively much greater when its water content was increased. It is usual to interpret this observation by pointing out the danger to all structures erected on filled or unconsolidated or water-soaked ground. It might be equally pertinent to recognize its bearing upon attempts to interpret seismograph movements recorded at points similarly exposed. With the study of local earthquakes particularly is coupled the need for full geological knowledge of the region and its ground-

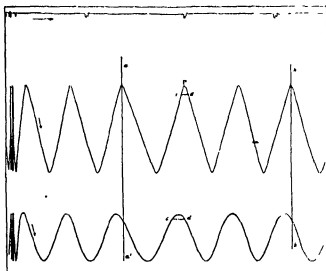


Fig. 1.—Upper curve represents actual movement of the sand. Lower curve represents actual movement of the containing box.

water relations lest the earth-wave itself may have suffered unsuspected distortion somewhere between epicentre and instrument. There are even many seismometers which for one reason or another do not rest upon igneous-rock foundations and contrariwise few earthquakes have their origin in homogeneous igneous rock.

There is a similar situation in the application of the Rossi-Fofel Scale and the determination of isoseismal lines which perhaps found expression in some of the difficulties which Commander Heck has just portrayed to you. Such an arbitrary scale of intensities may be worth

¹ F. J. ROGERS in Report of the California Earthquake Commission (A. C. LAWSON, Chairman), Carnegie Inst. Wash. Pub. No. 87, 1: 326, 1903.

much or little, according to the experience of the man who applies it. A chimney on a hillside, or in a valley adjacent, will suffer quite differently in the same earth movement. Indeed at Santa Barbara the destruction in the plain at State Street was rated at IX or X, Rossi-Forel, while the hillside, no more than two or three city blocks distant, showed no damage which could be rated higher than V or VI, even though located between the same portions of the active faults and somewhat nearer to one of them (Santa Ynez) than is State Street. Such crude classification partakes but little of a quantitative character and seismograph tracings are frequently subject to similar limitations, particularly in the records of local earthquakes.

These, very briefly, are difficulties which stand in the path of the student of local earth movements, and at the very beginning of the path, other and greater ones wait beyond.

GEOPHYSICS—*Pressures in planetary atmospheres.*¹ P. G. NUTTING, U. S. Geological Survey.

The total normal pressure (weight) of any single component of a planetary crust or atmosphere is proportional to its mass and independent of its physical state or chemical associations. The distribution of that pressure is not. Completely vaporized at high temperatures it exerts a uniform pressure over the planet's surface but when partly fluid or solid or when not entirely dissociated from other substances not completely vaporized its pressure may be largely localized. It seems worth while to examine such conditions in some detail, particularly as to their bearing on the isostasy of the surface. Many numerical data on vapor pressures and solubilities are lacking but the argument is fairly simple.

Take the case of water on the earth for example. The critical temperature is about 374°C. and the critical pressure 217.8 atmospheres, pressures being expressed in atmospheres and temperatures in °C. on the absolute scale (Data of Holborn 1919). The water of the earth covers 70.82 per cent of its surface of 196,950,000 sq. miles to a mean depth of 3681 meters or 2.287 miles (Data supplied by U. S. Coast Survey 1926). The waters of rivers, lakes, the atmosphere, polar ice, ground waters and combined waters are quite negligible by comparison. The oceans therefore contain sufficient water to cover the entire earth to a uniform depth of 2607 meters. At temperatures exceeding 374°C. all waters must be atmospheric and con-

¹ Received March 21, 1926.

tribute a fixed amount, 252.3 atmospheres, to the pressure uniformly distributed over the surface. This is considerably in excess of the critical pressure (217.8 atm.) of water.

The vital point in isostasy is that at 374°C. 13.7 per cent of the water was deposited as fluid upon the earth's surface, 86.3 per cent remaining in the air. This fluid suddenly deposited amounted to sufficient to cover the entire earth to a depth of 357 meters or 1171 feet. Local pressures (at the lowest point) may well have amounted to 3000 feet or more of water. This discontinuity in pressure was pointed out and discussed in a paper by the writer in *Science*, October 6, 1911. Not alone as regards isostasy but chemically and geologically, this abrupt precipitation of a seventh of the earth's water at such an elevated temperature and tremendous pressure must have been the greatest epoch marking point in the earth's geologic history. Had there been

TABLE 1.—PRECIPITATION AND PRESSURES AT VARIOUS TEMPERATURES

TEMPERATURES		PRESSURE ATMOSPHERES	$\frac{dP(\text{atm.})}{dT(\text{deg.})}$	$\frac{dP/P}{dT/T}$	VAP. PRESS. WATER (METERS)	PER CENT PRECIPITATED
°C	Abs.					
0	273	0.006025	0.000447	20.25		100
50	323	0.1217	0.00605	16.057		100
100	373	1.000	0.0358	13.353		100
150	423	4.698	0.1272	11.452	38.21	99.53
200	473	15.34	0.3237	9.981	148.2	94.2
250	523	39.24	0.666	8.876	395.2	84.8
300	573	84.80	1.210	8.170	865.9	66.6
350	623	163.21	2.000	7.634	1676	35.7
370	643	207.5	2.513	7.788	2234	14.3
374	647	217.8			2240	14.1

14 per cent less water on the earth, there would have been no such great discontinuity in the earth's life.

With the exception of a few metals, all minerals (even quartz) give way before water at or near its critical temperature and pressure. The first solid crust to form, namely the carbides freezing* at 4600°, could last but a short time while the oxides, forming at lower temperatures, would rapidly become hydrated and attack each other. Solution and erosion would proceed at enormous rates.

At temperatures below 374° precipitation rapidly increases with lowering of (mean annual) temperatures as shown in Table 1. For example at 300°C. the water is $\frac{2}{3}$ precipitated as fluid on the earth's surface while the remainder, equivalent to a column 865.9 meters high is vaporized and constitutes over 98 per cent of the pressure of the

* WILLIAM R. MOTT. *Trans. Amer. Electrochem. Soc.*, p. 235, 1918.

atmosphere. Some writers have wrongly assumed that at temperatures just above 100°C. the oceans would have all left the earth. Such is far from being the case. Even at 200°C. only 6 per cent of the water would be vaporized.

Pressure due to other components than water vapor and the permanent gases considered above would lower the proportion of water vaporized given in the table. However very few substances (mercury, sulphur, CO_2 , SO_2 , . . .) have a vapor pressure as high even as one atmosphere at 374° and these are either too scarce to need consideration or are locked up in compounds of still lower vapor or dissociation pressures.

When the water was all vaporized the atmosphere was of course very much deeper than at present, water vapor extending out perhaps 1000 miles or $\frac{1}{4}$ the earth's radius. Although heavily blanketed by material of low heat conductivity, conditions were favorable for steep thermal gradients in the outer layers and therefore for copious local (high level) precipitation. It is very doubtful whether such rain ever reached the surface. The thermal gradient from poles to equator was probably slightly less than at present.

Water has been chosen as an example because of its abundance and the simplicity of its behavior. Nearly complete data of high precision are available and anyone with a knowledge of elementary physics can rough out the problem. The molecular weight of water differs but little from that of the nitrogen-oxygen atmosphere so there is but little tendency to segregation. Nor are there other abundant substances having closely related thermal properties to complicate matters.

Next to be considered are the oxides of iron (7 per cent), aluminum (15 per cent) and silicon 60 per cent of the earth's crust 10 miles deep according to F. W. Clarke as compared with 7 per cent for water. Both SiO_2 and Al_2O_3 reach a vapor pressure of about one atmosphere at about 2200°C. with dissociation into oxygen and metal already in an advanced stage. It appears highly probable that these oxides are completely dissociated at temperatures far below those at which any considerable fraction would be vaporized. At high temperatures therefore we have to consider not fused and vaporized oxides but oxygen and fused metals with their vapors. Since the mass of the oxygen is about 7 times that of the water present on the earth, atmospheric pressure at 3000 to 3500° would be about 2000 atmospheres or 15 tons per square inch. Oxygen would reside at all levels since there would be but little tendency to segregate. The heavy metallic vapors (of Si, Al, Fe, Mg, Ca and Na) on the other hand would

tend to remain largely near the surface on account of their higher molecular weights. In this temperature region (3000–3500°) gases and vapors also become ionized by thermal agitation and therefore self luminous and good radiators of short wave radiation. This would tend to equalize temperatures by more rapid heat exchange. There was no precipitation of fluids from the outer cooler portions of the atmosphere upon the surface of the earth.

In summary, the history of the earth and of other planets of similar composition may be thus sketched out on a temperature rather than a time scale.

1. At 5000° and above. No solids present. Atmospheric pressure 20 to 30 tons per square inch. The atmosphere over 90 per cent oxygen with water vapor and free hydrogen in the outer layers and metallic vapors near the surface.

2. 4800 to 4600°. First solid crust formed consisting of metallic carbides, probably in thin scattered patches. Atmosphere as above.

3. 4600 to 3000°. But little variation in conditions. Luminosity decreasing rapidly with temperature. A few more carbides became solid. Practically no other compounds in any state except liquid alloys.

4. 3000 to 2000°. This is the great period of oxydation. Hydrogen and the more abundant metals first form stable oxides. All or nearly all in a molten condition with only water vaporized to a large extent.

Atmospheric pressure drops from about 20 to about 3 tons per square inch due to removal of nearly all the free oxygen from the gaseous state. But for the protective action of the superficial layer of oxides formed but very little oxygen would have been left. The amount of water formed limited by the amount of hydrogen present.

5. 2000 to 400°. This wide range like 3, was one of many minor changes but with little outstanding. A thick crust of oxides chiefly silica and silicates is being formed with some chlorides and sulphides. The original scanty patchy crust of metallic carbides probably deeply buried by silicate minerals. Water still all vaporized and not effective for hydration of surface minerals.

6. 374°. One seventh of the water precipitated to the surface as fluid. Atmospheric pressure dropping abruptly from 3700 to 3200 pounds per square inch. This water (sufficient to cover the entire earth 1170 feet deep) would accumulate in the lowest levels probably half a mile deep.

7. 374 to 300°. This is the period of hydration, solution, erosion, chemical changes and mineral formation, all proceeding at a rate

difficult of conception. Metallic oxides are hydrated to acids and alkalis in enormous quantities. All forms of silica and silicates are soluble and play a major rôle (in a minor key). Carbides are of course decomposed wherever water can reach them, the final result presumably being carbon dioxide. Within this temperature range the ocean increased to 4 times its initial, and $\frac{2}{3}$ its present volume. Torrential rains of almost red hot water at very high pressures changed whole landscapes over night. Sedimentation miles in thickness was a matter of but a few years instead of aeons as at present.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY

931ST MEETING

The 931st meeting was held at the Cosmos Club on Saturday evening, February 6th, 1926. The meeting was called to order by Vice-President Heyl at 8:15 with 50 persons in attendance.

BYRON E. ELDERED: *Physical observations on hearing and deafness.* Helmholtz stated that the mechanical problem which the apparatus within the drum of the ear had to solve was to transform a motion of great amplitude and little force, such as impinges on the drumskin, into motion of small amplitude and great force such as had to be communicated to the fluid of the labyrinth. Were this the only problem the ear of the bird would best serve the purpose as it provides the simplest mechanism:—that of the large and small diaphragm connected by a single rigid member. The ossicular arrangement is Nature's device for slow moving animals. It serves the further purpose and solves another problem of regulating the force imparted to the labyrinthian fluid.

The human drum apparatus may be considered to function as a variable transformer. In normal hearing there is accommodation for varying force of air wave vibration. This accommodation or adjustment for reception is explained by the functioning of the tensor tympani muscle in response to the indicating nerves of the external layer of the drumhead.

Failure in accommodation of the muscle control is emphasized as the probable cause of ordinary deafness uncomplicated by disease. Otosclerosis is suggested as a more probable result of deafness than its cause. Movable joints in the human system consigned to extended temporary inaction become sclerosed.

A minimum of force of air wave vibration is required for hearing in a normal person and greater force for one of defective hearing. The drumskin collects the resultant force of many air wave vibrations which are transmitted to the ossicles as a compound mechanical vibration to become in the perilymph varying pressures in liquid where analysis takes place into the simple vibrations which afford the sense of hearing.

Certain sustained noise vibrations furnish the force required for many deaf persons. Ordinary speech combines with these noise vibrations and is heard.

The force vibration may be one of inaudible frequency and effect the same result. If the force waves are too strong, then the deaf ear, by accommodation protects itself against this force and the ability to hear normal voice is lessened. The compounded vibration is evidently diminished in force. This explains the difficulty experienced with normal hearing under noise conditions.

If a substantially sinusoidal air wave vibration of suitable force is furnished certain deaf people experience sustained hearing ability for hours after a few minutes exposure to the wave. Continued daily use has evidenced a cumulative effect in many cases where regular use of the instrument for several months has been resorted to, the period of better hearing extending from a few hours after the primary application of the wave to several days after the later ones.

Investigation shows that a comparatively few congenitally deaf are without some degree of hearing. It has likewise been demonstrated that most congenital deafness is due to defects of the middle ear. The results of a large scale test conducted at a public deaf mute institution have demonstrated that greatly increased hearing can be developed by the application of the peculiar wave vibration of this invention.

The theory is advanced that human infants are born protected against inner ear reception of vibration and it is suggested that abnormal protection may be attributed as the cause of many case of congenital deafness (*Author's abstract.*)

H. A. MARMER, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The Ore Deposits Club met at the Geological Survey on March 26 to discuss informal contributions on the subject of *Field methods and equipment*

At the regular meeting of the Columbia Historical Society on April 20 Dr. EDGAR T. WHERRY gave an illustrated lecture on *Wild flower cultivation*.

The regular April meeting of the Petrologists' Club, held at the Geological Survey on April 6, was devoted to a discussion of *The rôle of water in magmas*. The discussion was opened by G. W. MOREY of the Geophysical Laboratory.

The Pick and Hammer Club met at the Geological Survey on March 27. E. F. BURCHARD outlined his visits to iron and manganese ore deposits in several South America countries, and J. T. SINGEWALD of Johns Hopkins University described his 1925 exploration of the headwaters of the Amazon in Peru.

Dr. J. G. THOMSON of the London School of Tropical Medicine, exchange Professor with Johns Hopkins Medical School, Baltimore, Md., visited laboratories of the Bureau of Animal Industry and the Bureau of Plant Industry, and attended the 95th meeting of the Helminthological Society of Washington, Saturday night, April 18, 1926.

J. E. SANDERS, JR., magnetic observer of the Carnegie Institution of Washington, cabled his arrival on April 22, at Cotonou, Dahomey, after a successful series of magnetic observations along the Niger River in French West Africa.

Dr. A. C. LAWSON has been appointed to represent the American Geophysical Union at the Fourteenth International Geological Congress, at Madrid, May 26-30, 1926.

Amundsen's ship *Maud* was recently purchased by the Hudson's Bay Company and renamed the *Baymaud*. She is to be used near Boothia Felix.

JOHN LINDSAY has been appointed delegate from the Carnegie Institution of Washington to the Pan-American Congress at Panama City, June 18-25, 1926.

Dr. C. G. ABBOT, Assistant Secretary of the Smithsonian Institution, has just returned from a six months journey to Algeria, Baluchistan, and Southwest Africa for the purpose of selecting a location for a solar observatory to measure the variations of the sun. This project is under the auspices of the National Geographic Society which is supplying the funds for erecting and maintaining the observatory for four years.

Dr. ABBOT has chosen Mt Brukkaros, altitude 5200 feet, situated about 60 miles to the northwest of Keetmanshoop, Southwest Africa. The rainfall in this region averages $3\frac{1}{2}$ inches a year; the clearness is extraordinary, and the prospects for fair observing weather are regarded by him as superb.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 16

MAY 19, 1926

No. 10

GEODESY.—*Gravity work at the second meeting of the International Geodetic and Geophysical Union.*¹ EMMANUELE SOLER, Royal University of Padua. (Communicated by W. D. LAMBERT.)

The International Geodetic and Geophysical Union, which was formed after the war for the purpose of promoting and coördinating investigations in geodesy and geophysics, held its first meeting at Rome in May, 1922. At this meeting there was but little discussion of gravity work.

The writer presented a note: *The establishment of an international gravity net (Sullo stabilimento di una rete gravimetrica internazionale)* which was published in the *Bulletin Géodésique* (No. 2, April, 1923), issued by the Section of Geodesy of the Union, and was intrusted with the duty of drawing up an international report on determinations of gravity between 1912 and 1922 and also some account of those made in 1922-24. This report, which is now in press and which contains 600 determinations of gravity made in this period, and also an account of the work in 1922-24, were presented at the Madrid meeting.

The facts brought out by the report, both in regard to the variety of instruments and in regard to certain diversities in the methods of observation and calculation prevailing in the various countries, brought home to the Section of Geodesy of the Union the necessity of appointing an international Committee on Gravity² to consider the various questions raised in the report and to establish general rules for coördinating gravity work.

In the first place the Committee recognized the difficulty of pre-

¹ Translated from the *Memorie della Società Astronomica Italiana*, Vol. III, New Series, by W. D. LAMBERT, U. S. Coast and Geodetic Survey.

² The Committee was as follows: E. Soler, Chairman; other members, Bowie, Ferrier, Neithammer, Leno, Conyngham, Matsuyama; A. Vening Meines, Secretary

scribing a single type of instrument for determining gravity, since it would be only unwillingly that the various countries would give up the instruments made in their own machine shops, or devised by their own geodesists. Instead of this, the committee deemed it desirable to recommend uniform standards both for the work of observation itself, and more especially for computing the precision of the resulting determinations of gravity; these standards can be applied whatever may be the pendulum apparatus used and whatever the method by which time is determined, whether astronomically or by radiotelegraphy.

The rules for the conduct of observational work deal especially with the following matters: (1) the desirability of continual verification of the constancy of the pendulums, a matter which may be tested by returning them frequently to the national base station, or to some other connected with the latter by determinations of great accuracy; (2) the method of arranging the pendulum observations with reference to determinations of time, and the limits of admissible error, which will vary with the importance of the station considered.

In regard to the computation of the precision of the results, on the proposal of Meinesz and of Niethammer it was recommended that account be taken: (1) of accidental errors of the period of the pendulums, as deduced from the values of the period of oscillation observed at a single station; (2) of the errors in the period which are constant at a single station but which vary from one station to another according to the laws of accidental error; (3) of errors more or less systematic in nature. For each of the above classes the errors intended to be included were specified.

The committee laid down certain criteria to be applied in the rather troublesome computation of the so-called topographic correction,² to be applied to correct the observed period of oscillation, for the effect of matter lying above the geoid and extending to a distance of 40 km. at least from the station.

It was voted to proceed with the correction, and this with all attainable precision, of certain national base stations, particularly of those neighboring countries which are members of the Union, that is, at the present time: Madrid, Paris, DeBilt, Proviantgaarden (Copenhagen), Uccle, Cambridge, Basel and Padua; some of these stations are not included in the international gravity net adjusted by Borras

² [This is the topographic correction (Geländereduktion) of Borras's reports on gravity. It is applied because the topography above the geoid is conceived as condensed upon the latter to form a surface layer of density proportional to the elevation. It is not the correction for the topography in isostatic calculations.—Translator.]

in 1909. This connection when made and the adjustment of the resulting net will form a supplement to Borress's work.

The Committee again expressed the opinion that theoretical gravity should be calculated by Helmert's formula of 1901.

In this way and by means of the standards referred to above, which are given in full in the minutes of the Committee soon to be published,⁴ conclusions were reached on some of the most interesting problems encountered in measuring gravity.

With regard next to the much-debated question of isostasy it was deemed desirable to have the values of gravity corrected not only by the classic methods of reduction of Faye⁵ and of Bouguer, but also by the isostatic method, according to the methods proposed by Hayford and Bowie. At the instance of the committee on gravity the Section of Geodesy voted that those countries which might not desire, or might be unable, to establish an office for computations of this sort might apply to the U. S. Coast and Geodetic Survey which, after suitable financial arrangements had been made, would perform the computations for the gravity determinations made by the countries in question.

This decision has the advantage of opening the way to a knowledge of the so-called depth of compensation in various parts of the world by means of uniform methods of calculation and therefore of increasing the value of the conclusions that may be derived from this knowledge.

To complete the chronicle of the discussions on gravity at Madrid let me mention two important communications.

The first one referred to certain fundamental changes which might be introduced into gravity apparatus. General Ferrié and Colonel Perrier presented some remarks regarding a method which is being tested at Paris by the Service Géographique de l'Armée. In this method gravity is determined by means of special light waves emitted during the fall of a body.

Bowie referred to an apparatus of Michelson's⁶ still in the experi-

⁴ A brief summary of the deliberations of the committee is published in the Bulletin Géodésique, No. 4, (1924).

⁵ [Faye's reduction = free-air reduction. Mr. G. R. Putnam has applied the term *Faye reduction* to a method, also used by Faye, in which the Bouguer reduction is applied to the topography between the level of the station and the "general level of the surrounding country" and the free-air method to the vertical distance between the general level and sea level.—*Translator*.]

⁶ Cf. W. BOWIE, *Isostatic Investigations and Data for Gravity Stations in the United States established since 1915*. (U. S. Coast and Geodetic Survey, Special pub. No. 99, Washington, 1924).

mental stage at Washington, with which gravity is determined by measuring with the interferometer the flexure produced by a weight applied to a quartz fiber and suitably arranged on the fiber itself. The second interesting communication was made by Vening Meinesz and dealt with the determination of gravity at sea.

Meinesz, who had studied in Holland a way of eliminating the effect upon the oscillations of the pendulum of those small movements of the ground, which are quite noticeable in that region, by means of a method based on the simultaneous swinging of several pendulums, believed that the same method could be applied to eliminate the effect of the motion of a vessel situated at some little depth below the surface of the sea, and that therefore it could be used in a submarine submerged to a depth of about 10 meters below the surface.

He used for the purpose a Stückrath outfit of four pendulums in the Dutch submarine KII and during the voyage of this vessel from Holland to Java he made determinations at 26 stations, some in harbors and some in mid-ocean.

The results, which are published in a note, *Observations de pendule sur la mer*, Delft, 1923, and were presented at Madrid, although provisional are very important.⁷ The Section of Geodesy therefore expressed the hope that all nations having navies might be willing to repeat these investigations.

* * * *

Thus has been summarized in outline the work pertaining to gravity that was accomplished at Madrid, work which, as is evident, fared far better than the work done at Rome during the first meeting. So without going into discussions of new forms of gravity apparatus which are not yet well known and which may perhaps displace the pendulum, it may be said that the decisions reached regarding the methods of observation and of computation are certainly such as to ensure greater homogeneity in gravity work and greater rigor, and thus to make the results lend themselves more readily to geophysical inferences.

At this point I should like to emphasize the subject of the connection

[Professor Soler may perhaps have confused the brief reference to MICHELSON's apparatus in Special Pub. No. 99 with an oral account of the apparatus devised by Dr. F. E. Wright of the Geophysical Laboratory of the Carnegie Institution of Washington. In Michelson's apparatus the deflections of a small cantilever beam of quartz are measured with an interferometer; in Wright's apparatus the distortion of a coil spring made of quartz and loaded with a weight is measured on a graduated circle.—Translator.]

⁷ MEINESZ has informed me that he is making modifications in the instruments used in the first voyage.

of this work with geophysics. Without dwelling upon the ever-glorious traditions of geodesy, it is certain that in all countries there has been accumulated an enormous mass of geodetic data.

This does not represent, however, merely a necessity of the past. The lively and interesting discussions in the Section of Geodesy at Madrid regarding the choice of an international ellipsoid of reference prove that this is a question of present-day interest. And it is a question that involves not merely theoretical necessity but also practical convenience.

It is well known theoretically that, whatever ellipsoid may be chosen to represent the earth's surface, there are always deviations of the latter from the *geoid*. It remains for geodetic research to determine these deviations in the best way, to deduce from them the curvature of the *geoid* and to give some idea as to the possible effect of these deviations on the determination of gravity.

But the practical point of view is no less important, since by the choice of a convenient ellipsoid the connections between the triangulations of adjoining states are made more certain, the results of leveling are rendered more valuable, and the solution of the various problems of a practical nature more simple. This ellipsoid should fulfil the following conditions: (1) the local deflections should be reduced to small amounts; (2) it should have only small deviations from the *geoid*; (3) it should be possible to pass by small changes of the semi-axes from this ellipsoid to the several regional ellipsoids used in various countries for their triangulations. The subject of a suitable ellipsoid is therefore not exhausted by classical investigations and always leaves open the way to further studies, which likewise have a practical bearing.

The fact that in investigating this ellipsoid of reference the results of astronomic methods were combined with more modern results from measurements of gravity is one of the many strong claims to distinction of the illustrious Helmert, who in 1901 calculated an ellipsoid from determinations of gravity known up to that time. This same ellipsoid now serves and will continue to serve, as has previously been mentioned, for the calculation of the theoretical values of gravity.

Thus the geodesists are applying to their fundamental—and inexhaustible—problem methods ever more and more modern, and these methods depend on results, like those of gravity determinations, which, along with others depending on determinations of longitude differences, latitude variations, and so forth, make up an aggregate of work which the geodesists, in addition to that done for their own special purposes, are making available for geophysical research. It is certain that this

work will go on being continually increased, discussed and modernized; but is likewise certain that it cannot be of use in geophysical problems unless serious steps are taken to secure the needful coördination.

Permit me to say here that as regards this coördination little has been accomplished so far by the International Union. At Madrid, as I happen to know, there was a meeting between certain delegates of the Section of Geodesy and the Section of Oceanography; from this resulted the decision to establish institutions for the study of earth tides in connection with oceanic tides. Certainly this is an important decision and one which may lead to interesting results in which geodetic investigations (leveling, etc.) may be combined with geophysical ones. Another meeting was held of the delegates of the Section of Geodesy and the Section of Meteorology and of Seismology, but as far as I recall, without practical results. All this is not very much.

The variety of problems is well known for which geophysics needs geodetic connections and in some countries, such as the United States, through the work of the Coast and Geodetic Survey, these connections exist and geodetic investigation with its application to problems of a geophysical nature goes on increasing. It is enough to mention the masterly investigations of Hayford and Bowie on isostasy. It is therefore to be hoped that it may be possible to establish within the Union closer relations between the various sections.

But, particularly as regards our own country, it is well to repeat the wish so competently expressed by Senator Volterra in his Presidential address before the Academy of the Lincei at its meeting of June 1, 1924, to the effect that not only should the National Committees take steps to unify by appropriate means the investigations of the various branches of the Union, but that institutions should also be established among us of a practical and experimental character, institutions which might bring about the necessary progress and the coördination needed in the various problems which bind together geodesy and geophysics.

Royal University of Padua.

January, 1925.

CHEMISTRY.—*Chemistry as a branch of mathematics.*¹ LEASON H. ADAMS. Geophysical Laboratory.

In selecting a title for this address, I have chosen "Chemistry as a branch of mathematics" in order that the title itself might emphasize

¹ Address of retiring President of the Chemical Society of Washington, January 14, 1925.

one of the important aspects of chemistry. It is my purpose to discuss some of the points of contact between chemistry and mathematics and to direct attention to the necessity of making more use of mathematical methods in chemical investigation.

Let us begin with a brief review of the origin and early history of chemistry, in order that we may better observe the place which it occupies among the other sciences and the general trend of chemical thought.

Alchemy. Chemistry had its origin in the ancient art, alchemy, which was first developed by the Alexandrian Greeks early in the Christian era. According to an old legend it was founded by the Egyptian god Hermes. For this reason the early alchemists were said to practice the hermetic art, and when they filled vessels with various mixtures and closed them up they placed on them the seal of Hermes, from which arose the term "hermetically sealed." The first well-authenticated event in the history of alchemy was the decree issued by the Roman emperor Diocletian in 290 A.D. ordering the destruction of certain books which contained, among other things, various recipes for making alloys simulating gold and silver and used in the manufacture of cheap jewelry.

It seems that originally these processes, which were kept secret by the priests, deceived only the outsiders, but that eventually the adepts succeeded also in deceiving themselves into believing that they could turn base metals, such as lead, into gold. This hope and belief furnished the incentive for chemical investigation—of a certain kind—extending over many centuries, first by the Greeks and Egyptians and later by the Arab and Roman alchemists. The development of alchemy took place along the theoretical as well as the experimental side, and if their experiments were few and inconclusive, their theories were numerous and detailed, as found in the abundant literature of alchemy. Many of these theories were founded on the idea of a *prima materia*, a single primitive matter of which all substances were composed. Other theorists, however, were more liberal as to the number of fundamental elements. Thus many adhered to Aristotle's system whereby the fundamental elements were earth, air, fire and water, while in the works of Basil Valentine sulfur, mercury, and salt were assumed to be the constituents of all metals. Perhaps the most interesting explanation of the genesis of metals is found in the writings of Vincent of Beauvais who held that there are four spirits—mercury, sulfur, arsenic, and sal ammoniac—and six bodies—gold, silver, copper, tin, lead, and iron. The metals are formed as follows: "Pure

sium, sodium and oxygen. Finally Berzelius replaced the geometric signs with the letters now used.

Mathematical notation. The use of characters to represent elements is the first indication of a mathematical trend in chemistry. For the essence of every branch of mathematics is a set of symbols which represent quantities, qualities, and operations. Thus, the symbol AB may represent the length of a line extending from a point A to a point B , or the direction of the line (say, northwest), or the result obtained by multiplying a number A by a number B . In mathematics a set of symbols enables us to write a kind of shorthand whereby a statement concerning the relation between a number of quantities and requiring many complete sentences can be condensed into a few strokes of the pen. For example, the following collection of symbols $(a + b)^2 = a^2 + 2ab + b^2$ is the equivalent of the statement that:

When one number is added to another number and when the sum is multiplied by itself the number obtained by this operation is identical with that obtained by multiplying the first number by itself and then adding twice the product of the two numbers and adding also the product obtained by multiplying the second number by itself.

To take an extreme case, the expression $R_{\alpha\beta}^{\mu}$, well known in a certain branch of mathematics, stands for a set of expressions¹ which would require many hours to state completely in plain English. In a similar but less striking manner every chemical equation is a statement in mathematical language of a number of facts concerning certain elements and compounds, and the difficulty of writing or speaking about chemical subjects without having recourse to the conventional symbolism can well be imagined.

To return to the history of chemistry: having been started in the right direction by the great hypotheses of Dalton and of Avogadro, the science developed steadily and ever more rapidly. The century that has just passed has seen chemists increase in number from perhaps a few dozen to tens of thousands; it has seen a vast accumulation of information concerning the properties and composition and reactions of substances; it has seen chemistry transformed from a mere hobby to a great branch of science and an indispensable factor in the world's most important industries. During this period workers in the field of chemistry were so occupied with measurement, with analysis and with synthesis that theory lagged far behind experiment. A great mass of uncoordinated and apparently unrelated data accumulated

¹ This is the Riemann curvature tensor; used in the theory of relativity

and by its very magnitude and unwieldy character forced the development of theories or laws to harmonize and simplify the known facts. Chemistry was thus driven slowly and inevitably into mathematical-physical channels.

Abstract reasoning. Let us now consider the two ways in which we may look at chemical problems. People may be divided rather sharply into two classes depending on their ability to view things in the abstract. One class has no difficulty in visualizing the meaning of symbols and in forming a mental picture from an equation. The other class finds it difficult or impossible to do this and prefers the written word or sentence rather than a symbol which stands for it. All equations are poison to these people. We have here a difference of temperament rather than training. Each class has its own mode of thinking and its own method of attacking problems. The one type is found more often among the physicists; the other among chemists. It seems that in schools and colleges too little allowance is made for this condition. The kind of mathematics customarily employed in physics presents very great difficulties to most students of chemistry. However, to teach "Functions of a Complex Variable" to an unwilling chemist is no more foolish than to eliminate mathematics entirely from his course of study. Actually the amount of pure mathematics required in most branches of chemistry is small. Elementary calculus is as far as most need go, but what is more important than any specific mathematical subject is to have a certain type of mental training, a mental training requisite for a proper understanding of the physical meaning of a formula. Most people realize that geometry is not taught to high school students because they are likely to have any practical use for the relation between the exterior angles of triangles, but rather because geometrical demonstrations teach them to think straight and to proceed in a logical manner whenever they attack any problem.

Mathematics is an abstract science while chemistry is essentially a concrete science, but progress in any branch of science will be most rapid when it makes full use of the tools which the mathematician has provided. This is more evident in physical chemistry than in organic chemistry or biochemistry, but because of the inherently greater difficulties these parts of chemistry have not developed so far. Already, however, the methods of physical chemistry are being made use of in nearly every branch of chemistry and, a start having been made, it is to be expected that much of the apparent aversion to mathematical methods will gradually disappear.

Let us now consider a few examples of the mathematical aspects of chemical investigation—first a brief description of the elementary mathematical devices which are of most general use, and second a mention of certain branches of chemistry which are most intelligible when allowed to speak in mathematical language.

The graphical representation of data. In nearly all kinds of investigation, it is necessary to measure something, and if one of the measured quantities depends solely on one other quantity it is common practice to plot a curve. "Order and regularity are more readily and clearly recognized when exhibited to the eye in a picture than when they are presented to the mind in any other manner." However, it is seldom that the full possibilities of graphical representation are realized. In many instances it is advantageous to plot one quantity against the logarithm of the other quantity. This can be done either by finding the logarithms and then plotting in the ordinary manner, or, more directly, by the use of special coordinate paper with a logarithmic scale. By this means, curves having a logarithmic or exponential shape³ become straight lines, or nearly so, and a straight line, of course, is much easier to draw and is more useful for extrapolation. In other cases it is convenient to use a double logarithmic scale⁴—so-called log-log paper.

Still more important for the chemist is a peculiar scale in which the logarithm of one quantity is plotted against the reciprocal of the other. This is almost indispensable when dealing with vapor pressures or with equilibrium constants, and it is very surprising to observe the large number of those in chemical work who are not familiar with this procedure.

The deviation curve is a valuable aid in plotting certain kinds of data. It is difficult to plot data accurate to one part in one thousand on a sheet of reasonable size. But by plotting the differences between the observed points and some arbitrary line which approximately fits the data, it is possible to obtain a satisfactory representation on a small sheet of coordinate paper and to show irregularities which are invisible on the ordinary plot.

Selection of an equation. This brings us to one of our most common difficulties—the selection of an equation to represent a given set of data. To this goal there is no royal road. It requires the use of the

³ That is, curves approximately represented by the equation $y = ab^x$, where x and y are the variables.

⁴ This makes a straight line of the function $x^a = by^c$.

simple mathematical devices which have been provided for us, combined with as much common-sense and experience as we can bring to bear on the problem. In general, the best procedure is as follows: First, it is advantageous to familiarize oneself with the appearance of a number of the simpler types of curves. Several of these¹ may be plotted on a convenient scale and kept for reference. Then, having plotted the data in question, we compare with the reference curves the shape of the curve so obtained, and if one is found which resembles the experimental curve we use this as a clue in replotting the data so that nearly a straight line is obtained. If satisfactory, we then use the graph to determine all but one of the constants of the equation and calculate the remaining constant from the equation and the data.

A more elegant method for determining the constant of the chosen equation is to use the method of least squares. This is a good plan—for those who can do it. Nearly as good results are obtained by averaging the points in groups so as to obtain as many "average points" as there are constants in the equation and then solving directly for the constant.

As a last resort, when all other methods fail, the data may be fitted to a power series

$$y = A + Bx + Cx^2 + Dx^3 + \dots$$

using enough terms to make the curve fit the data to a sufficient approximation. This is the most common method and the least satisfactory.

What has been said so far refers to the case of two variables only. With three variables (for example, P , V , and T) graphical representation requires the construction of a solid model, or the drawing of contours on a plane, while with four variables the case is hopeless unless one is clever enough to draw a projection of a four-dimensional surface on a three-dimensional solid.

The Phase Rule, and chemical thermodynamics. A great deal of the mathematical part of chemistry has centered around the Phase Rule. It was in 1875 that J. Willard Gibbs clearly defined component and phase and brought forth his famous generalization which stated that the number of phases in equilibrium could never exceed the number of components by more than two (thus, with a mixture of common salt no more than four phases can exist together), and that the system

¹ For example a simple parabola, $y = a + bx^2$, an hyperbola, $y = \frac{a}{x} + b$, a cubic,

$y = a + bx^3$, the exponential relations (footnotes 3 and 4), or the equation $\log y = \frac{a}{x} + b$.

gained an additional degree of variability, or degree of freedom, for each phase short of this number. It is safe to say that without the aid given by this rule a satisfactory investigation of the chemistry of solutions and complex mixtures would have been quite impossible. After being discovered by Gibbs the Phase Rule was unnoticed for many years, but was finally rediscovered and put to good use. We might wonder why this important Law should remain dormant for so long. The answer is found in the way in which it was first announced. On page 96 of "Equilibrium of heterogeneous substances"⁴ we may read as follows:

"If a homogeneous body has n independently variable components, the phase of the body is evidently capable of $n + 1$ independent variations. A system of r coexistent phases, each of which has the same n independently variable components is capable of $n + 2 - r$ variations of phase. For the temperature, the pressure, and the potentials for the actual components have the same values in the different phases, and the variations of these quantities are . . . subject to as many conditions as there are different phases. Therefore, the number of independent variations of the values of these quantities, i.e., the number of independent variations of phase of the system, will be $n + 2 - r$."

This is the Phase Rule. When we note that this paragraph occurs in the middle of a paper containing 300 pages of rather forbidding mathematics we should not be surprised that it escaped attention for so many years.

The Phase Rule was derived from the principles of thermodynamics and is only a part of a great system of chemical thermodynamics developed by Gibbs and published in a paper which is probably the most important paper in all physical chemistry.

Thermodynamics attempts to reduce to their simplest form all laws relating to chemical systems. It states that in a homogeneous mixture, i.e., a phase, the properties of the system are completely determined if we know four quantities, which are designated by the letters P , T , V , and S . Of these, the first three are readily understood to mean the pressure, temperature, and volume, respectively, of the given phase. The fourth stands for a quantity called entropy; and why, we may well ask, do we introduce this strange interloper among the other sane and respectable characters? The answer is that in no other way has it been found possible to deal with the laws of solutions in a direct, logical way and to take advantage of simple mathematical formulation.

The four quantities mentioned above are sufficient when we deal with

⁴ J. WILLARD GIBBS, *Scientific Papers* Vol 1: p 96

a system in which material is neither added nor taken away. To allow for variation in amount of each component we must add another quantity, μ , one for each component. There is a simple fundamental equation connecting the quantities P , T , V , S , and the μ 's, from which we can proceed, by what is really simple calculation, to the formulation of the freezing-point Law for solutions, or the laws relating to vapor pressure or osmotic pressure, or, indeed, any of the solution laws. The desired relations can be derived separately from the same starting point, or they can be combined in a single equation:*

$$(S'' - S') dT - (V'' - V') dP = m'_1 \frac{\partial \mu'_1}{\partial x'_1} dx'_1 - m'_2 \frac{\partial \mu'_2}{\partial x'_1} dx'_1$$

By a few strokes of the pen any of the solution laws can be written down at once, if this equation is before us. This applies to the ordinary case of two phases and two components. For more complicated cases a similar equation can be written.

This same system of physical chemistry can easily be made to take account of the additional factors, surface tension and the action of gravity. In the latter case we are enabled to write, without long calculation, an equation giving the difference in composition of a solution at the top and at the bottom of the vessel containing the solution. Furthermore, we may take account of another variable and deal with electrolytic cells, the E.M.F. of which can be connected with the properties of the substances which take part in the chemical reactions within the cell. It is for this reason that E.M.F. measurements have contributed so much in extending our knowledge of physical-chemical systems.

The thermodynamical treatment of chemistry is indispensable in a certain very interesting field of work, the study of the properties and reactions of systems under high pressure. If more time were at my disposal I should like to point out the ways in which certain simple mathematical methods are of service in such investigations. Suffice it to say that by taking advantage of the relations existing between apparently unrelated quantities it is possible to arrive at satisfactory results by indirect methods where it would be impossible to measure the desired effect directly.

Chemical affinity. At this point I wish to mention one of the con-

* In this equation the superscripts refer to the phases and the subscripts to the components. The total amount of one component in the given phase is m_1 , and its weight percentage is x_1 .

cepts of chemistry which has always proved of great interest. I refer to chemical affinity. This term has long been used in a vague way to indicate the force which causes atoms to combine and which determines whether or not a chemical reaction will proceed in a given direction. Thermodynamics has supplied the means of giving this qualitative term a quantitative significance. Instead of dealing directly with forces, we take advantage of the fact that a force may be measured by the work which it does, so that affinity is defined in terms of work or energy units. Thus the affinity of hydrogen for oxygen is measured by the work which may be obtained from the reaction in which they combine, and the affinity of hydrogen for chlorine may be defined in like manner. A quantitative comparison of the relative affinity of hydrogen for oxygen and for chlorine may then be made. It turns out that chemical affinity defined in the proper way is closely related to the quantity μ which occurs so prominently in all chemical thermodynamics; in fact, the two are nearly identical.

The mechanics of the atom. The last subject which I wish to touch upon is sub-atomic chemistry, that is, the nature of the interior of the atom. This most vital and fundamental part of chemistry has made great advances in the last two decades, having received its impetus through the discovery of X-rays and of radioactive substances. The internal structure of the atom is no longer a complete mystery. The physicists have apparently claimed this territory for their own, and it must be admitted that the great fundamental discoveries in this field have been made by physicists. Their remarkable progress has been largely due to the fact that they did not fail to use all possible mathematical tools including the most profound analytical methods.

The atom is now seen as a minute core or nucleus surrounded by a swarm of electrons, from 1 to 92 in number, at relatively great distances from the nucleus. The weight of the atom is determined mainly by the nucleus; practically all other properties are fixed by the number, position, or motion of the electrons. In particular, chemical valence depends mainly on the exterior electrons, and thus the idea of valence has come to have a fuller and more definite significance.

A number of new theoretical developments have led to great advances in our knowledge of the structure of the atom. In certain atoms the physics of their interior is so well known that the wavelength of light emitted by it is known not merely to within one per cent or to within one-tenth per cent, but to seven significant figures.

The study of the atom has been resolved into a question of mechanics, mechanics of a very queer kind involving the quantum

hypothesis, the theory of relativity, and other ultra-modern notions. There is evidence that in certain instances the electrons are revolving around the nucleus, and that in other cases they occupy relatively stationary positions. The final solution of these problems is not yet in sight. But it is not too much to expect that the interior of the atom, viewed as a problem in geometry and mechanics, will ultimately be completely solved and that we shall then be able to predict the properties of atoms and compounds, the reactions between them, and the possibility of the existence of unknown compounds. Chemistry will then have still more of a mathematical complexion.

In conclusion, I wish to quote some remarks by a distinguished chemist, Professor A. Crum Brown of the University of Edinburgh. More than thirty years ago he said:^a

"Another frontier of chemistry is that which looks towards those regions of physics which have come more or less completely under the control of the great empire of mathematics. And here both the work done from our side and that done from the mathematico-physical side has special interest for us. For we may expect chemistry to undergo a very great and revolutionary change when the frontier comes to be explored and cultivated. We shall then be separated by an imaginary line from the mathematical sciences, and mathematical methods will rapidly be applied to chemical questions. Chemical methods will still be used. The most perfect dynamical explanation of chemical constitution and chemical change will not enable us to dispense with the old processes of analysis and preparation. The chemist will still be the man trained in the chemical laboratory, and all the mechanical parts of the work will still be done by him. But, unless he learns the language of the empire, he will become a provincial, and the higher branches of chemical work, those which require reason as well as skill, will gradually pass out of his hands. This must not be, and the younger chemists can prevent it. Let them while there is time learn the language of the empire. Let them become fluent and ready in its use; let them read with care the work that is being done on the border between chemistry and mathematical physics, and, as they find opportunity, do such work themselves, and so be ready to take their part in the union which will certainly come."

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

186TH MEETING

The 186th meeting was held in the assembly hall of the Cosmos Club on the evening of Thursday, March 20, 1924.

Dr. R. M. YERKES, of the National Research Council: *Psychology as Social Biology*.

^a Trans. Chem. Soc. (London) 61: 478. 1892.

Psychology is now using the methods of the physical and biological sciences. At the same time it has important social objectives. On these grounds it may be considered a department of social biology. Recently differentiated from philosophy, psychology is actively engaged in trying to find itself and in delimiting its scope.

Confusion in the lay mind as to what psychology really is and may legitimately undertake to achieve is due largely to duality of interest and method within the science. On the one hand there is the subjective interest which promotes psychology as the study of the self (introspective psychology); on the other hand there is the objective interest and bias which limits attention to the study of behavior, one particular brand of which has come to be known as "behaviorism."

To the speaker both of these types of psychological interest appear legitimate and worthy of cultivation. The introspectionist and the objectivist alike have their opportunities to contribute to our knowledge of mental constitution. Their activities should be supplemental, and there is no apparent reason for fretting about their relative importance.

Since "human nature" is complex and highly variable, analysis is requisite to the successful measurement of traits. Most so-called "mental tests" measure we know not what! They undoubtedly are useful in the present desperately crude state of popular knowledge, but they are remote from the scientific ideal of method. The psychologist as investigator undertakes to measure specific and definite functions or "unit characters" of behavior. The majority of "testers" deal with human nature in large lumps and without much concern about their composition or the variability of their constituent parts.

Not a few laymen seem to believe that "test score," "mental age," and "intelligence quotient" are comprehensive, if not complete, descriptions of mental constitution. Instead, they are merely fragments of an ideally complete description, for experience and behavior are almost discouragingly many-sided. Even "intelligence" (defined as individually adaptive behavior) is complex, and its reasonably complete description would entail the measurement of scores if not hundreds of specific traits or functions. As in the case of physique, so in human behavior, many dimensions must be taken before we can safely compare individual with individual or group with group.

In a recent book by Dr. Rudolf Lämmel, *Intelligenzprüfung und psychologische Berufsberatung* (Oldenbourg, Berlin, 1923), the point here made is effectively visualized. By a system of polar coordinates the author simply presents the results of a reasonably comprehensive series of measurements of reactive capacity.

In Dr. Lämmel's figures, designated as "ingenogramms," the traits measured fall into eight principal categories, roughly translated as observational ability, memory, technical aptitude, attention and concentration, imagination, artistic ability, judgment or critical ability, and maturity. Within each category several traits or functions are measured. For instance, one ingenogramm represents the results obtained with a class of forty-four boys. A perfect circle represents the average for the group, since the average for each trait measured is arbitrarily located at a certain fixed distance from the center of the ingenogramm. The variability (plus and minus) of the average or mean is represented by polygons without and within the perfect circle. The innermost polygon of the ingenogramm represents minimal measurements for the group of individuals observed. The outermost polygon similarly represents maximal measurements.

By comparison with the ideal individual of the group, as represented by the perfect circle, there appear in this ingenogramm the figures which indicate the measurements obtained from the poorest pupil in the class and for the best pupil. Thus the ingenogramm makes possible ready comparison of the reactive traits or capacities of an individual with the average or ideal for his age, sex, race, etc., or with any other individual.

The value of the ingenogramm of course depends upon the nature and value of the traits which are chosen for measurement and the accuracy of the observations. Granted reasonable wisdom in choice and accuracy of measurement, it would appear highly desirable that each of us, for educational, vocational, and varied other purposes, be provided with his ingenogramm! (*Author's abstract.*)

Dr. L. L. THURSTONE of the Carnegie Institute of Technology, Pittsburgh: *Psychology in employment.*

187TH MEETING

The 187th meeting was a joint meeting with the Botanical Society and was held at the Administration Building of the Carnegie Institution of Washington on the evening of Monday, March 24, 1924.

Prof. JEAN MASSART, of the University of Louvain: *The internal sensations of Araucaria excelsa.*

There are six kinds of buds on *Araucaria*: (1) A terminal bud, (2) the dormant buds of the main stem. These can develop into nothing but main stems, no matter how they are treated or where they are placed. (3) The active buds at the tips of the primary branches, (4) the dormant buds on primary branches. These can develop into primary branches. (5) Active buds at the tips of subordinate branches, and (6) dormant buds on subordinate branches. These can be made to develop only subordinate branches.

A number of experiments were set forth, showing in most striking fashion that each of these classes of buds was able to develop only in its own fixed way. Some of the experiments shown had continued for more than twenty years.

Experiments were also shown to demonstrate the exchange of stimuli from one part of the plant to another. A plant, for example, was grown with one half in bright sunlight and the other half moderately shaded. The shaded half soon became unhealthy and died, though another plant, the whole of which was shaded, was not injured by the same degree of shading as was fatal to the part of the plant which remained partly in the sunlight.

When the plant is turned into a horizontal position the primary branches, which originally came out at equal angles around the stem, are raised or depressed, as the case may be, to bring them closer to the horizontal position they normally occupy.

When a plant was turned up-side-down and its axis prevented from bending upward by a weight, the older lateral branches gradually twist to bring their leaves into the original dorsi-ventral position. Twisting begins at the tip of the branches and gradually proceeds toward the base. In young branches where dorsi-ventrality had not yet been established the face now upward became dorsal and that downward became ventral without any twisting or turning. A plant that had been left in the reverse position for several months was again turned to a normal position. The old branches twisted again into either the same or the reverse direction to assume their proper dorsi-ventral attitude in the new position, but the young branches, which had assumed the reverse position without twisting bend up and over the top of the plant, assumed their proper dorsi-ventral attitude on the opposite side of the stem, forming by their bending a curious twist at their bases. (*Abstract by R. F. GRIFFS, Secretary of Botanical Society*)

188TH MEETING

The 188th meeting was a joint meeting with the Chemical Society and was held in the assembly hall of the Cosmos Club on the evening of Thursday, May 15, 1924.

Prof. LEANOR MICHAELIS, of Berlin: *The theory of acid-base equilibria and its application to biochemistry.*

189TH MEETING

The 189th meeting was a joint meeting with the Chemical Society and was held in the Auditorium of the Interior Department on Tuesday on the evening of October 7, 1924.

Prof. S. B. L. SORENSON of Copenhagen: *Osmotic pressure of protein solutions.*

190TH MEETING

The 190th meeting was a joint meeting with the Philosophical Society and was held in the assembly hall of the Cosmos Club on the evening of Saturday November 1, 1924.

Prof. HENRY NORRIS RUSSELL of Princeton: *Recent advances in our knowledge of the stars.* Author's abstract appeared in THIS JOURNAL: 15, 17, 1925.

191ST MEETING

The 191st meeting was a joint meeting with the Philosophical Society and was held in the assembly hall of the Cosmos Club on the evening of Saturday, November 15, 1924.

Professor CHARLES FABRY of Paris: *Thirty years in spectroscopy with the interferometer.*

The speaker gave many personal reminiscences and told of the difficulties encountered with primitive, home-made apparatus, very different from the finely finished instruments now in use.

192D MEETING

The 192d meeting was a joint meeting with the Chemical Society of Washington, the Baltimore Section of the American Chemical Society, and the Medical Society of the District of Columbia, and was held in the assembly hall of the Cosmos Club on the evening of Thursday, December 11, 1924.

Lieutenant Colonel E. B. VEDDER of Edgewood Arsenal: *The toxicity of lead tetraethyl and other substances.*

A number of men handling lead tetraethyl recently in two large factories became ill and some died, and there has been much newspaper talk about "insanity" or "loony" gas, names given to the ethylated gasoline, and its distribution has been prohibited in New York City. Literature was cited showing that while the ordinary symptoms of lead poisoning are of a chronic nature, lead encephalopathy, the symptoms of which do not differ markedly from those of lead tetraethyl poisoning, is of frequent occurrence. As reported by physicians, the symptoms of poisoning by lead tetraethyl are as follows: The blood pressure and body temperature fall, and the heart action becomes low; there are digestive disturbances, such as loss of appetite, vomiting and diarrhea; vertigo may be present; the red blood corpuscles show marked changes, and the blood becomes noncoagulable; there is no cyanosis, shortness of breath nor headache, but following these symptoms there are in severe cases other phenomena indicative of profound cerebral disturbances. There are persistent insomnia, delusion, extraordinary restlessness and talkativeness; the gait becomes staggering like that of a drunken man but there is no

paralysis nor convulsions there is exaggerated movement of the muscles and the patient becomes violently maniacal, a condition that is not remedied by morphine. The lethal dose by skin application is 0.6 cc and 0.3 cc per kilogram respectively for guinea pigs and dogs, but an animal can be easily saved if washed within a half hour after exposure with kerosene followed by tincture of green soap. The toxicity of phosgene by inhalation is about ten times that of lead tetraethyl and mustard gas is about twenty times as toxic yet these are manufactured by the ton with safety. In the manufacture of this substance workmen should be protected against its vapors and the possibility of getting the compound on their skin. Gas masks and gasoline should always be at hand in case of accident. There is some public hazard as the result of the general use of ethyl gas, both through skin application and by inhalation, but the author assumes that this may be reduced to very small proportions by issuing proper warnings and by education. No cases of poisoning following the distribution of ethyl gas have been reported, nor have animals subjected to the exhaust gases from ethylated gasoline suffered any noticeable ill effects that could be attributed to lead poisoning. Carbon monoxide is infinitely more dangerous in a closed garage.

Lead tetraethyl is such a valuable commercial asset that it cannot be permitted to be dropped. Before it can be permitted to come into general use adequate provisions must be made for its safe manufacture, and quite extensive studies should be made as to the possible poisonous accumulative action when it is used over long periods of time. (*Abstract from author's paper by V. K. CHESTNUT, Secretary pro tem of Chemical Society*)

Col. VEDDER also made a brief statement regarding the use of chlorine in the cure of colds. Lack of success by others has been found to be due to the fact that the optimal concentration was not employed.

193D MEETING

The 193d meeting was a joint meeting with the Archeological Society and the Anthropological Society, and was held in the auditorium of the New National Museum on Tuesday, December 16, 1924.

Count BYRON KHUN DE PROROK. *The Carthage excavations of 1924 and the dead cities of the Sahara.* The site of ancient Carthage is one of the most beautiful in the world. The ruins of the city stand on a peninsula sixteen miles north of Tunis. Excavations there have been made spasmodically for forty years, but barring the Punic Tombs discovered by Father Delattre, only a single solitary Punic ruin has been found. This is being excavated at the present moment and is revealing each day new light on the art and religion of a lost empire.

The ruins of the first Carthage are still beneath the surface of the other layers of different civilizations. In one portion of the excavations seven strata of different periods of man have been uncovered—seven cities one above the other!

Ancient Arab Carthage has produced some beautiful examples of glazed pottery. The crusade of St. Louis of France in 1370 left some interesting coins. The Byzantines, who ruled there for over a hundred years, have also left traces of their dominion—a church, several houses, fortifications, and debris of all sorts. The Vandals destroyed more than they left, and though coins and armor and tombs of the Vandal period exist, yet it is mostly of their predecessors, the Romans and the early Christians, that we find the greatest number of ruins and remains. The aqueduct, the theater, the odeon and vast cisterns have been partly uncovered, but the wonders of Carthage to be

visible today are the early Christian basilicas that have been found by Father Delattre, the great French scientist and dean of the North African explorers. It is due to him also that at Carthage there is one of the finest though least known museums in the world filled with treasures of many empires.

Carthage was the first city to use paving stones, and the historians speak of its houses as being seven stories high. Such edifices must have left foundations and it is our hope to find traces of the roads and forum of Punic Carthage this winter. Another site that is still a great mystery is that of the ancient ports. For several hundred years the vast fleets and armies engaged in the Punic wars sailed from the ports of Carthage. That is why we are starting extensive excavations to locate the harbors from which so much history sailed. From the ancient historians, Appian, Polybius and Pliny, we know that these ports were one of the wonders of the ancient world. They were two in number, the military port and the commercial port. A splendid circular colony made of giant columns surrounded the military port, in between which were hauled up the galleys. From the admiral's palace all the operations of the two great ports could be seen, and the fleets could be manoeuvred and directed from one point. A channel to the sea was guarded at night with a mighty chain. Our efforts this winter will be centered on locating the quays and in digging shafts into the ground in search of the forum or agora that we know from the historians was adjacent to the ports. It is in this quarter that we are excavating the Temple of Tanit recently discovered. This is the first clue to Punic Carthage and it is producing great results.

In the work of this important clue to a lost civilisation many scientists and students come from different institutions. The Abbé Chabot of the French Institute took charge of the deciphering of the Punic inscriptions. Messrs. Icard and Grosseille of Tunis made the plans and drawings. Mr. Harden of the University of Cambridge was cataloguer and Mr. Barriere of the New York Times was photographer. The excavations were supervised by the director of the government services, by Mr. Duff of Oxford University and by myself. This is to give an idea of what a large staff is needed, in a single excavation. All the earth removed has to be sifted, often by hand sieves. Coins, jewels, cameos, amulets, beads, etc., etc., have been recovered this way in quantities. Five thousand coins have been dug up in six weeks.

The great depth of the excavation is also one of the great problems, and sometimes tons of earth have to be carried to the sea. The earth deposited on Carthage in the hollows between the hills, has been calculated to be as much as one yard a century! This means digging down twenty yards to get to the city that Scipio destroyed in 146 B.C.

The great romance of excavation is not only the objects and monuments of lost civilisation that we may find, but also the revealing of new historic dates and the links between different races. For instance, near the rock bottom of the temple of Tanit, which means the oldest period, we have found traces of a great Egyptian influence, and the problem now presents itself: Were the people of the Pharaohs here before Dido and her Phoenicians?

We are also excavating an early Christian chapel filled with early Christian sculptures, inscriptions and statuettes. These statuettes are of great importance to the history of the early Catholic Church. (*Author's abstract.*)

The address was illustrated by moving pictures. Afterwards an opportunity was given to examine some of the objects described in the address.

WALTER D. LAMBERT, *Recording Secretary.*

THE PHILOSOPHICAL SOCIETY

932D MEETING

The 932d meeting was held at the Cosmos Club on Saturday evening, February 20, 1926. The meeting was called to order by President BOWIE at 8:18 with 58 persons in attendance.

LOUIS A. BAUER: *Are sun spots the direct cause of the earth's magnetic storms?* (Illustrated by lantern slides.) The remarkable and rapid increase in the number and size of sunspots during recent months and the severe magnetic storm of January 28th, which was accompanied by brilliant displays of polar lights and notable interruptions in telegraphic transmission, has called renewed attention to the precise relationship between eruptive solar phenomena and disturbances in the earth's magnetic condition.

In August, 1923, occurred the minimum average frequency of sunspots expressed by the relative number 0.5; sunspots of small area occurred chiefly on two days (20th and 21st) of that month. The average relative frequency of sunspots in December, 1923, was 2.8, in December, 1924, 16.5, but in December, 1925, it had risen to 100. It would not be surprising if the maximum relative frequency of sunspots occurred during this year (1926)—only 3 years after the year of minimum frequency. In general, the interval between the years of minimum and maximum sunspot frequency is about 5 years, and the interval, termed the solar cycle, between successive years of minimum, or of maximum, sunspot activity, is about 11½ years. It has occurred before that the interval between minimum and maximum sunspot-teness was as short as 3 years; for example, 1766-1769, 1775-1778, 1784-1787 and 1867-1870.

The chief conclusions resulting from the investigations of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington are as follows:

a. An exhaustive examination shows that none of the present measures of the sun's activity are adequate to explain the occurrence and magnitude of disturbances in the earth's magnetism. The energy required to produce a sunspot appears to be of a different character and magnitude from that required to derange the earth's magnetism, to cause polarlight displays and to interrupt telegraphic transmission on overhead and underground lines.

b. Neither the number, area, nor position of spots on the sun's visible disk may be taken at present as a safe index for the prediction of the occurrence of magnetic storms, or of the production of the electric currents in the earth's crust which are responsible for interruptions in telegraphy. There are at times notable magnetic storms on the earth when there is no visible disturbance on the disk of the sun presented to the earth.

c. While, on the average, there is a very high correlation between solar activity and the earth's magnetic activity, from year to year during a solar cycle, the correlation does not seem to be one of cause and corresponding effect, but rather one indicative of the fact that solar disturbances, and magnetic disturbances are effects of one, as yet undiscovered cause, which may simultaneously affect the condition of the entire sun. (*Author's abstract.*)

C. W. KANOLT: *The work of the Cryogenic Laboratory of the Bureau of Mines.* The Cryogenic Laboratory of the Bureau of Mines was established in 1921 for the purpose of supplying scientific data required for the designing and the efficient operation of plants for the production of helium from natural gas and plants for the repurification of helium after it had become contami-

nated with air during its use in airships. The work of the laboratory consists largely of determination of the properties at low temperatures of the constituents of the natural gas from which helium is separated by low-temperature fractionation. The properties investigated include vapor pressures, gas solubilities, specific and latent heats, and the liquid-vapor composition relations of mixtures. Also, special physical apparatus for use in helium plants has been developed. The research methods employed in the laboratory were described, without the presentation of numerical results. (*Author's abstract.*)

933D MEETING

The 933d meeting was held at the Cosmos Club on Saturday evening, March 6, 1926. The meeting was called to order by President BOWIE at 8:16, with 70 persons in attendance.

The program for the evening consisted of four papers constituting *A Symposium on Earthquakes*. The first paper was by F. A. TONDORF on *Earthquake study in the past—a retrospect*, and was illustrated with lantern slides. The second paper was by N. H. HECK on *Some important problems in seismology*, and likewise was illustrated with lantern slides. The third paper by WILLIAM BOWIE dealt with *Earthquakes from the isostatic view point*. The last paper was by A. L. DAY on *Local earthquakes*, and was illustrated with lantern slides. These papers appeared in full in the issue of the *Journal of the Washington Academy of Sciences* for May 4, 1926.

The papers were discussed by Messrs. HUMPHREYS, L. H. ADAMS, STOKELY, and HAWKESWORTH.

934TH MEETING

The 934th meeting was a special meeting held jointly with the Washington Academy of Sciences and the Chemical Society on Thursday, March 18, 1926, at the Cosmos Club. The meeting was called to order by President SMITHERS of the Chemical Society at 8:15 P. M., with about 200 persons in attendance.

The program for the evening consisted of a paper by Dr. EDWIN E. SLOSSON on *The chemical interpretation of history*.

H. A. MARMER, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The annual excursion of the Petrologists' Club took place on May 7 and 8, with sixteen in attendance. The territory covered was principally in the South Mountain region of Pennsylvania near the Maryland line and about ten miles west of Gettysburg. The party proceeded from Washington by automobiles and spent the night of the 7th at Gettysburg. Among the features of special interest were: the "Devil's Racecourse," a boulder flow in the Cambrian quartzite region; outcrops of the pre-Cambrian basalts and rhyolites; sericite schists resulting probably from tuffs; unusual crystals of piemontite, a manganese epidote; piemontite schists and greenstone schists, quarried for use in making colored roofing materials; and copper ores, including native copper, occurring in associations similar to those of the Lake Superior copper district. G. W. STOSE and E. T. WHERRY acted as guides for the party.

The Pick and Hammer Club met at the Geological Survey on April 24. F. E. MATTHES spoke on *Glaciation of San Jacinto Park in southern California*, and C. K. WENTWORTH demonstrated his device for projecting topographic maps into block diagrams.

The annual meeting of the District of Columbia Chapter, Society of the Sigma Xi, was held at the Bureau of Standards on May 3. R. H. SARGENT of the U. S. Geological Survey gave an illustrated lecture on *Discovery of volcanic craters of unusual nature on the Alaskan Peninsula*. The lecture was preceded by five-minute contributions to knowledge by E. E. SLOSSON on *Soya bean oil products and synthetic rubber*; W. T. LEE on *The Carlsbad caverns*; R. B. SOSMAN on *A newly-discovered discontinuity just beneath the granitic shell of the earth*; R. F. GRIGGS on *A comparison of Katmai with the craters described by Mr. Sargent*; and E. C. CRITTENDEN on *The excessive sensitivity to red light of red-color-blind persons*.

Mr. K. Y. TSUKUDA in charge of the Magnetic Chart and Marine Meteorological Division of the Imperial Marine Observatory, Kobe, Japan, called at the various Scientific Bureaus while on a visit in Washington.

Mr. O. W. TORRESON of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington will leave the Magnetic Observatory at Watheroo, Australia, early in June to return to Washington.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 16

JUNE 4, 1926

No. 11

GEODESY.—*The equilibrium theory of the earth's crust.* GEORGE R. PUTNAM. Washington, D. C.

It is now generally accepted that the crust, or outer portion of the earth, is in a condition of equilibrium, called isostasy. Under the great and continuous pressures exerted, the solid materials of which the crust is composed act to some extent as if they were plastic, and elevations are, so to speak, floated and depressions sunk by the relatively lighter or heavier materials of which they are composed or by which they are underlaid. I became interested in this subject over 30 years ago. So much has been written about isostasy since, that I would not feel justified in again recurring to this early work, were it not that, because of the way in which it was published, there has been some misapprehension regarding it.

The early work referred to was the measurement of the relative force of gravity made by me in 1894 and 1895 at 34 stations in the United States, and the statements of the results for these and other stations published in 1895 and 1896.¹ The field work was for the most part planned by Mendenhall, then head of the Coast and Geodetic Survey, and was the first extensive use of the portable pendulum apparatus developed under his direction, largely by E. G. Fischer. The stations were systematically distributed across the continent, at points well suited to bring out the general facts as to crustal conditions, including a station on the summit of Pikes Peak. I had the assistance of Charles Mendenhall, now of Wisconsin University, on the mountain part of this work.

While the task assigned me was to make the observations, in putting the results into shape, with reduction to sea level by the then cus-

¹ PUTNAM. Coast and Geodetic Surv. Report for 1894, Appendix No. 1, pages 9-37. 1895. Phil. Soc. Washington Bulletin 13: 31-56. 1895. Amer. Jour. of Sci. 1: 186-192. March, 1896.

tomary methods, one on the theory of a rigid crust, and the other a crude application of isostasy, I was impressed by the significance of this series, and by the fact that those two methods both signally failed to remove all the large anomalies, and that therefore neither gave clear evidence as to crustal conditions.

The idea of isostasy had been expressed by Airy in 1855, and by Pratt in 1859, as an explanation of anomalies in plumb line deflections in India, and was also advanced to account for the anomalies in gravity results from pendulum observations in India in 1865. In 1880 the French astronomer Faye² suggested that while elevations in general are in a condition of equilibrium, the gravity results would be more harmonious if certain features of moderate size were allowed for as supported loads, and he gave as illustrations the Great Pyramid of Egypt, a single hill or mountain, and the "pillar" of an oceanic island. He did not however apply this idea.

The so-called free air reduction was an attempt to apply a compensation correction to gravity observations by ignoring the attraction of all material above sea level. A comparison in 1895 of the resulting anomalies, with the topographic situations of the stations showed a striking relationship, with large positive anomalies where the stations were above the average elevation, and the reverse for stations below. So I applied a leveling off process, estimating the average elevation of the country about each station within an arbitrarily assumed radius of 100 miles, and then allowing for the attraction of the mass between the station elevation and the average elevation, subtractive or additive as the station was above or below the average. This in effect applied approximately an isostatic compensation sufficient for the average elevation of the region about a station, instead of for the station elevation itself. In application it simply added another term to the free air reduction. On the idea of isostasy, this was a logical procedure, as the trouble with the free air reduction was that it ignored the fact that gravity at any station is appreciably affected not only by the compensation immediately beneath that station but by the resultant effect of the compensation of the surrounding area for some distance, and in regions where the

² FAYE C. R. Acad. Sci. 90: 1443. 1880. Because of the suggestion in this paper of allowing for certain supported loads, in 1895 I used the term Faye reduction. FAYE however never applied the idea or developed a formula. To avoid confusion which has arisen, and also because the reduction I developed is not dependent on the idea of supported loads, I have since called it the average elevation reduction, as it adds to the free air reduction formula a term to allow for isostatic compensation for the average elevation of the region about a station.

point of observation was much above or below the average elevation the resulting over or under compensation was shown by the large free air residuals. In this investigation I used 67 stations, including previous determinations in several continents, and island stations in two oceans, a group of stations exceptionally well placed to throw light on isostasy. Quantitatively the method was effective, as for the first time in gravity reductions, the large residuals disappeared.

In 1909, after having tested the theory of isostasy by means of deflection of the vertical data, Hayford made an important advance by developing a method of reducing observations of the force of gravity taking account for the first time of the curvature of the earth's surface and of the compensation of all the topography of the earth.¹ He assumed a condition of perfect local isostasy, a depth of compensation derived from his deflection investigations and uniform vertical distribution of compensation. He reached important conclusions by comparisons of the anomalies with those of older methods. In this work he used 72 gravity stations, 56 of which are in the United States. The investigations were later greatly extended by him and by Bowie. They constitute the most thorough investigation that has been made of the bearing of gravity observations on the condition of the earth's crust, and they yielded gravity residuals which are probably more significant than any heretofore.

But it developed that the 1895 reductions had given anomalies on the average approximately as small as the later more rigid work. The reason for this was explained later. The investigations of Hayford and Bowie² have indicated that there is practically no difference between the average anomalies based on an assumption of perfect local isostasy and those based on an assumption of regional compensation, which implies some local rigidity, to a radius of 37 miles from the station, and it is not shown that the same may not be true for a somewhat larger radius. For an area included within a radius of 104 miles they concluded that there is a marked advantage for local isostasy. While there is probably close isostatic adjustment for areas smaller than this, the average anomaly differences are still rather small even to the radius of 104 miles, and there is a little additional evidence in favor of regional compensation to this limit, as for example that derived from neighboring pairs of stations.³

¹ HAYFORD. Report, International Geodetic Association, App A: 365 1909.

² HAYFORD and BOWIE. Coast and Geodetic Surv. Spec Pub 10: 98-102 1912, BOWIE. Coast and Geodetic Surv. Spec Pub. 40: 85-92. 1917.

³ PUTNAM. Bull. Geol. Soc America 33: 290-301. 1922.

Therefore the results of the method used in 1895, which was equivalent to applying approximately an adjustment to each station to compensate for the average elevation of the surrounding region, are not affected by whether local features are considered as regionally supported loads or not. Within the limits of the approximations used the results should be similar to those by the Hayford method.

TABLE 1—COMPARISON OF GRAVITY ANOMALIES

STATION	STATION ELE- VATION	AVERAGE ELE- VATION WITHIN 100 MILES	ANOMALIES, g OBSERVED, 1.000 g COMPUTED			
			Bouguer reduc- tion	Free air reduc- tion	Average eleva- tion reduc- tion Putnam, 1895	Hayford reduc- tion 1915
	meters	meters	dynes	dynes	dynes	dynes
Washington, D C (Smithsonian) Coastal region	10	0	+0 023	+0 024	+0 023	+0 039
Deer Park, Md Allegheny Mts ridge.	770	479	-0 045	+0 032	+0 003	+0 010
Ithaca, N Y. Lake region ..	247	345	-0 055	-0 031	-0 021	-0 023
Denver, Colo Western plateau .	1,638	2,212	-0 207	-0 048	+0 008	-0 016
Pikes Peak. Rocky Mt summit	4,293	2,258	-0 231	+0 234	+0 014	+0 021
Grand Junction, Colo Rocky Mt. valley	1,398	2,251	-0 184	-0 044	+0 041	+0 024
Norris Basin, Wyo. Rocky Mt region	2,276	2,137	-0 197	+0 038	+0 024	+0 021
Salt Lake City, Utah Western plateau	1,322	1,894	-0 171	-0 045	+0 010	+0 010
Mt Hamilton, Calif Coast mountain summit	1,282	80	-0 031	+0 093	-0 022	-0 003
San Francisco, Calif Pacific Coast ..	114	-280	-0 009	-0 028	-0 039	-0 023
Seattle, Wash Coastal region	74	530	-0 127	-0 135	-0 071	-0 093
Juneau, Alaska Coastal valley .	5	800	-0 039	-0 047	+0 046	+0 037
St Georges, Bermuda Atlantic Island	2	-2,400	+0 225	+0 214	-0 029	+0 020
Saint Paul Island, Alaska. Bering Sea Island	12	-80	+0 041	+0 032	+0 034	0 000
Honolulu, Hawaii Pacific Island, coast	6	-1,930	+0 202	+0 192	-0 002	+0 054
Mauna Kea, Hawaii Pacific Island, summit	3,981	-1,670	+0 252	+0 630	+0 076	+0 185
For 42 stations, range of anomalies			0 507	0 765	0 147	0 278
Mean, regardless of sign			0 104	0 068	0 025	0 024
For 25 United States stations, range of anomalies			0 278	0 316	0 086	0 062
Mean, regardless of sign			0 117	0 039	0 018	0 014

They do agree, on the average, to a degree which is rather unexpected when the generalizations of the 1895 reductions are considered, but as I pointed out, the methods of computation were too approximate for the individual residuals to have much significance. For the most part, however, they show the same trend as the Hayford anomalies.

Table 1 illustrates the foregoing by comparison of anomalies for stations significantly located, using the four reduction methods.

The summary at the end includes all stations for which a direct comparison of original results could be made. A full comparison, and explanation of the reductions, were published in 1922.⁶ Most weight should be given to the United States stations, and these show a small but appreciable advantage for the 1912 results.

The 1895 investigation included 15 oceanic island stations in the Pacific and Atlantic Oceans and Bering Sea, and for these the weight of surrounding sea water, as well as the configuration of the sea bottom, was taken into account in computing the compensation due to average elevations.⁷ The results for these oceanic island stations were in good conformity with those for the continental stations.

At the time, I stated⁸ that the 1895 results indicated "that local topographical irregularities" are "maintained by the partial rigidity of the earth's crust," and I meant, by this, features of the order of a single mountain, as suggested by Faye. I did not conclude that mountain systems or larger continental areas are upheld, and I did not use the words "mountain ranges," which in this connection are ambiguous. The 1895 results furnished strong evidence of the existence of isostasy to a fairly close but not determined limit, but it has since developed that they did not furnish proof as to the support of local features. The results with the Hayford reduction method give very strong evidence of the correctness, to a close limit, of the theory of isostasy, but as shown above, for areas of 37 miles radius, or possibly larger, they give indeterminate results as between regional and local compensation. Such a feature as a single mountain would generally fall within an area of this size, and thus the gravity investigations do not determine whether a mountain is regionally supported or locally compensated. A mountain is in general undoubtedly compensated, but it is probable that through partial rigidity the compensation is distributed beyond the area of the base, as a part of the compensation of the surrounding region; the method of distribution is, for obvious reasons, difficult to detect with the pendulum. Visible evidence on the surface of the earth shows that the strength of its materials is sufficient to maintain for long periods nearly vertical rock walls of great height. It is highly improbable that there is such a condition of compensation below the surface as to support locally and separately the rock walls and the contiguous valleys of the Glacier Park region, for example, or the gorge and the side walls of the Grand Canyon of the Colorado.

⁶ PUTNAM. Bull. Geol. Soc. America **33**: 291-299. 1922.

⁷ PUTNAM. Coast and Geodetic Survey, Rep. 1894, App. No. 1, 26-29. 1895.

⁸ PUTNAM. Coast and Geodetic Survey, Rep. 1894, App. No. 1; 25. 1895.

At the request of the Superintendent of the Coast and Geodetic Survey, Gilbert, a well-known geologist, took part in the 1894 work by making a geological examination of some of the stations, and he also later discussed the results with respect to isostasy.⁹ His computations and conclusions were quite independent of mine, and I had no responsibility for them. While convinced of general isostasy, his conclusions as to the extent of regionally supported features were much broader than anything suggested by me, and in fact his discussion rather disregarded my warning that "it is probable that no particular significance attaches to these residuals remaining," and the fact also that I attached no significance to the arbitrarily selected radius for the average elevation about the station. His work, however, had the valuable effect of pointing the way to the interest of the gravity results to geology. Gilbert in a later paper¹⁰ completely discarded his deductions of 1895, and I refer to them now only because the conclusions he discarded have inadvertently been ascribed to me.¹¹ Their publication at the same time without comment is explained by the state of knowledge at the time, and inexperience on my part.

Hayford wrote me a letter, March 11, 1922, which I would not quote but for its quite direct bearing on the purpose of this note. Referring to my paper of 1922,¹² he says: "In general I am fully in accord with it. It seems to me that what you did was to reach a close approximation, in 1895, to correct conclusions, based on evidence that convinced you but which did not at that time fully convince others. The fact that later, and much more abundant, evidence treated much more rigorously gives conclusions in such close agreement with those reached by you, emphasizes the validity of your work, and also strengthens the conclusions from the later work."

I have pointed out the superiority of the recent methods. The 1895 investigations, however, arrived at a fairly close approximation to the same results by a very simple computation method.¹³ Be-

⁹ GILBERT. Phil Soc Washington Bulletin 13: 61-75 1895. .

¹⁰ GILBERT. U. S. Geol. Surv. Prof. Paper 85-C. 1913.

¹¹ BOWIE. Bull. Geodesique, 6: 2. Memoir of Hayford 1925 Scientific Monthly, 23: 7 1926

In these two references there has been some misapprehension in stating my views, ascribable to the earlier manner of publication.

¹² PUTNAM. Bull. Geol. Soc. America 33: 287-302. 1922.

¹³ National Research Council. International Critical Tables. 1: 1926. SWICK, *Variation of Gravity with Elevation*, page 402 Under "more exact methods" for computing the value of the acceleration of gravity at a point on the earth's surface, the average elevation method, similar to the formula developed in 1895, is given as follows: "In mountainous country, the computed value will be practically as close to the true

sides their interest historically, they have also a value, as mentioned by Hayford, in showing that similar conclusions as to general crustal conditions are reached by a quite different method of computation, and in indicating how a combination of approximate assumptions may yield results on the average quite close to those of the more elaborate method. There may be a tendency to take more literally even than their authors intend the truth of combinations of assumptions, the probability of which may appear to be indicated by the smallness of averages. For example, it is fairly obvious that there is no sharply defined depth of compensation, that the depth in which there is some compensation effect varies in different regions, and that there is not a uniform vertical distribution of compensation, these being assumptions that were made for mathematical convenience.

An impressive fact as to the earth is that all the varied features of its so-called crust are in a fairly close state of equilibrium, and a conclusive proof of this fact has been furnished by the study of the oscillations of the pendulum.

PETROLOGY.—*Rocks of Eastern China.*¹ H. S. WASHINGTON and MARY G. KEYES, Geophysical Laboratory, Carnegie Institution of Washington.

INTRODUCTION

Attention has previously been called to the paucity of our knowledge of the chemistry of the igneous rocks of China.² Of the igneous rocks of that country—with an area of one-half that of the United States—only about 25 analyses have been published, and few of these are of good quality and of fresh rock. In order partially to supply this deficiency, Dr. L. F. Yih, Director of the Geological Survey of China, at the request of the senior author, kindly sent him 24 specimens of the igneous rocks of eastern China from the Survey collections. For this kindness and courtesy we would express our hearty thanks.

value as in flat country if an additional term is added to the right hand side of equation (1) (free air reduction), to take account of the elevation of the place above or below the general level of the topography within a radius of, say, approximately 160 km. For every 10 m. the place in question is above the general level, this term amounts to 0.001 cm./sec.², and for every 10 m. below the general level, it amounts to -0.001 cm./sec.². In computing the height of a coast station above the general level, the water must be considered replaced by an equal mass of rock, of average surface density, resting on the bottom of the ocean."

¹ Received May 6, 1926.

² CLARKE and WASHINGTON, U. S. Geol. Survey Prof. Paper 127: 66. 1924.

The present paper aims only at giving petrographical descriptions and chemical analyses of the specimens at our disposal, the descriptions having been written by the senior and the analyses made by the junior author.

Literature. The literature on the petrography of China is not abundant. Of the more general works, that of Pumpelly⁴ need not be considered, as it antedates the use of the microscope. Von Richthofen⁵ in general names the rocks only from field observations, and he gives no detailed petrographical descriptions. Blackwelder⁶ contributes a chapter on the rocks collected in northern and central China by the Carnegie Expedition of 1903-4, with many petrographical descriptions but without analyses. The rocks collected in northwestern and central China by the Futterer-Holderer Expedition of 1898 have been described by Andree and Schwartzmann, with a few chemical analyses.⁷ Deprat⁸ gives many descriptions, with some good analyses, of the rocks of Yunnan in southwestern China. Koch⁹ describes the rocks of northern China collected by the Szechenyi Expedition, but without analyses.

Shorter papers are those by: Pabst,¹⁰ who describes rocks of Kiangsi used in porcelain manufacture; Schwerdt,¹¹ who describes von Richthofen's specimens from Shantung and Liautung; Steuer,¹² who gives a few brief descriptions of granites from Kansu and Shensi; L  vy and Lacroix,¹³ who describe rocks from southern China; Rinne,¹⁴ with good descriptions of rocks from around Kiau Chow in Shantung; Wong,¹⁵ who deals with the petrography of Hsi Shan, west of Peking, in Chihli, Yih, describing the geology; and Norin,¹⁶ who gives a good description of a syenitic area in western Shansi, some of the rocks of which we have analysed.

⁴ PUMPELLY, *Smithsonian Contrib. Knowl.*, **15**, 1867.

⁵ VON RICHTHOFFEN, *China*, **2**, 1882.

⁶ BLACKWELDER, in Willis, Walcott, et al, *Research in China*, Carnegie Inst. Publ. No. **54**: 1 (2) 357-476, 1907.

⁷ FUTTERER, *Durch Asien*, **2**, part 2, *passim*, 1909, **3**, part 4, 61-116, 1911.

⁸ DEPRAT, *M  m. Serv. G  ol. Indochine*, No. 1 (1), 1912.

⁹ KOCH, in *Wiss. Ergeb. Reise Graf Bela Szechenyi*, **3**: 364. 1899.

¹⁰ PABST, *Ztsch. deutsch. geol. Ges.*, **32**: 223. 1890.

¹¹ SCHWERDT, *Ztsch. deutsch. geol. Ges.*, **38**: 198. 1886.

¹² STEUER, *Neu. Jahrb. Beil. Band 10*: 478. 1895.

¹³ L  VY and LACROIX, *C. R. Acad. Sci.*, **130**: 211. 1900.

¹⁴ RINNE, *Ztsch. deutsch. geol. Ges.*, **56**: 122. 1904.

¹⁵ WONG, in Yih, *Mem. Geol. Surv. China*, No. 1: 32. 1920.

¹⁶ NORIN, *Bull. Geol. Surv. China*, No. **3**: 45. 1921.

PETROGRAPHY

Alaskite. The best specimen of alaskite is one from Chow Kow Tien, in Hsi Shan (Western Hills), in Chihli, a granite from which, poor in quartz, is described by Wong. Our specimen is white, rather fine-grained, composed almost wholly of white orthoclase and less quartz, with very few scales of biotite and small, opaque, black grains. In thin section the feldspar is seen to be uniformly a slightly turbid, untwinned soda-orthoclase, with abundant quartz, the texture being granitic. The very rare, small biotites are light yellow; there are some small, elongated crystals of colorless titanite, (mentioned by Wong as common in granite); a few magnetite grains, but no pyroxene. The black, apparently opaque grains, under high powers, are slightly transparent on thin edges, with a dark red color and marked pleochroism: they are referred to one of the sodic amphiboles, aenigmatite or cossyrite. Much altered specimens that appear to be alaskite, are those from Ma Shan, Chao Yuan Hsien,¹⁶ Shantung, which is reddish and porphyritic, and may be the tsingtauite of Rinne or the rhyolite porphyry of Blackwelder; from Ssu Tze Shan, Hunan; and from Ki Ling An, Fan Chang Hsien, Anhui (Ngan Hwei), which is aplitic.

The chemical analysis (No. 1 of Table 1) is that of a somewhat sodic alaskite, with almost equal amounts of the orthoclase and albite molecules. The small quantity of sodium metasilicate shown in the norm obviously belongs, with the normative aenmite and diopside, to the sodic hornblende;¹⁷ while the small percentages of normative rutile and wollastonite go to form the titanite. The rock is clearly of sodic affinities.

Granite. Various kinds of granite are very abundant in China. Two specimens were studied. A *biotite granite* from Lai Yang Hsien, Hunan, is fine-grained, made up of white feldspar, quartz, and small biotites. The thin section shows a typically granitic texture. The feldspar is dominantly untwinned orthoclase, with less, finely twinned oligoclase; they and the quartz grains inclose a few small crystals of colorless titanite; the thickish tables of pale brownish biotite are fresh and clear. There are a few magnetite grains, but neither pyroxene nor amphibole is present. The chemical analysis of this specimen (No. 2 of Table 1) calls for no special remark, except that all the

¹⁶ Hsien = district. Shan = mountain.

¹⁷ This has been shown for the lavas of Pantelleria (Washington, Jour. Geol., 22: 22, 1914).

normative hypersthene must enter biotite and, with the necessary amount of orthoclase and a little of the magnetite and ilmenite, thus forms about 15 per cent of this mica.

TABLE 1—ROCKS OF EASTERN CHINA*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SiO ₂ . . .	73 10	65 63	63 93	63 65	62 72	61 05	54 18
Al ₂ O ₃ . . .	12 95	14 69	16 86	13 57	12 70	16 49	16 11
Fe ₂ O ₃ . . .	0 60	1 30	2 78	0 64	1 21	1 01	3 62
FeO . . .	0 60	3 01	1 22	1 68	1 71	3 97	4 68
MgO	0 22	1 58	0 67	3 61	3 44	3 00	5 00
CaO . . .	0 66	2 97	4 33	5 15	4 85	5 61	8 40
Na ₂ O . . .	4 90	3 23	5 42	4 90	5 25	3 09	3 92
K ₂ O . . .	5 75	4 56	2 33	3 73	3 43	3 53	1 33
H ₂ O+ . . .	0 36	0 55	0 54	0 43	0 43	0 53	0 03
H ₂ O- . . .	0 01	0 08	0 07	0 03	0 12	none	0 01
TiO ₂ . . .	1 26	2 05	1 12	1 80	3 07	1 67	2 02
ZrO ₂ . . .	n d	n d	none	0 02	n d	n d	n d.
P ₂ O ₅ . . .	0 05	0 19	0 37	0 17	0 45	0 14	0 12
S	n d	n d	0 03	0 05	n d	n d.	n d.
Cr ₂ O ₃ . . .	n d	n d	none	0 01	n d.	n d	n d
MnO . . .	0 01	0 08	0 04	0 06	0 04	0 01	0 08
BaO . . .	n d	n.d.	0 09	0 08	n d.	n d.	n.d.
	100 47	99 92	99 80	99 58	99 42	100 10	99 50

Norms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Q	25 02	20 70	15 06	9 54	9 12	13 20	4 20
Or	34 47	27 24	13 34	21 68	20 02	20 57	7 78
Ab	33 54	27 25	45 59	41 39	44 54	26 20	33 01
An	—	11 95	15 29	4 17	1 11	20 85	22 52
Ac	1 85	—	—	—	—	—	—
Na	1 34	—	—	—	—	—	—
Di	1 30	1 76	2 59	15 98	15 77	4 94	14 52
Hy	—	4 36	0 50	1 60	1 30	8 94	8 02
Wo	0 70	—	—	—	—	—	—
Mt	—	1 86	4 18	0 46	—	1 39	5 34
Il	1 22	3 95	2 13	3 50	3 65	3 19	3 80
Ilm	—	—	—	0 32	1 28	—	—
Ru	0 64	—	—	—	1 12	—	—
Ap	—	0 34	0 34	0 34	1 01	0 34	0 34

(1) Alaskite, I' 4 1 3 Chow Kow Tien, Hsi Shan, Chihli.

(2) Biotite granite, I(II) 4 2 3 Lai Yang Hsien, Hunan.

(3) Augite granite, I(II) 4 2 4. Shang Ch'ien Pu, Wu An Hsien, Honan.

(4) Quartz syenite porphyry, II.(4)5 1(2). 4. Chin Ling Ch'in, Shantung.

(5) Quartz syenite porphyry, II.(4)5 1 4. Tien Shan, Iu Tu Hsien, Shantung.

(6) Granodiorite, II 4 3 3 3. Hsiao Chi Sheh, Lung Jen Hsien, Fukien.

(7) Andesine andesite, II'.5.3.4. Hsi Ma Ho, Mongolia

* MARY G. KEYES, analyst.

A specimen from near Shang Ch'ien Pu, Wu An Hsien, Honan, is an *augite granite porphyry*. This is light gray, with small (2-4 mm.) phenocrysts of dull, slightly pink feldspar and small prisms of black augite in a very fine-grained but phaneric groundmass. Microscopically, the phenocrysts of orthoclase are fairly euhedral, stout crystals, with rough outlines and somewhat turbid in the interior. A few phenocrysts of oligoclase also occur. The rough prisms of augite are of a pale, slightly greenish, yellow. The fine-grained groundmass is typically granitic. Magnetite grains are few, and there is no biotite, amphibole, or titanite. The chemical analysis (No. 3 of Table 1) shows that the rock is decidedly sodic and that the amount of quartz is not large.

Quartz syenite porphyry. Two specimens that fall here come from Chin Lin Ch'in and from Tien Shan, Ih Tu Hsien, both in Shantung. They resemble each other so closely in all respects that the two localities probably are near each other or belong to the same petrographic district. They are fine-grained, aplitic-looking rocks, with small phenocrysts of white feldspar and some of black augite, in a very fine-grained, phaneric groundmass. Both specimens contain small dark xenoliths of pyroxenite. The thin sections show short, thick tables of fresh, considerably twinned microcline, with little quartz. The augite phenocrysts form stoutish, ragged prismoids, of a pale, brownish yellow color, and are not very fresh. The groundmass is granitic, composed of some quartz and more turbid feldspar. Neither specimen contains biotite, amphibole, or magnetite grains, but in that from Ih Tu Hsien there are some small crystals of colorless titanite. The chemical analyses of the two specimens (Nos. 4 and 5 of Table 1) are much alike and show that the feldspar is a sodic microcline or a potassic albite.

Biotite granodiorite. Only one specimen, from the southeasterly province of Fukien, represents this rock, but it would appear to be fairly abundant in eastern China, to judge from the descriptions by Koch and by Blackwelder. The rock is rather fine-grained, with granitic texture, made up of much fresh feldspar, many small scales of black biotite, and a little quartz. The microscope shows that the abundant feldspar is in part multiply twinned andesine, about $Ab_{40}An_{60}$, with less untwinned orthoclase. The thick tables of rather dark brown biotite carry no inclusions; there are few crystals of light yellowish augite, slightly altered, but no amphibole. Grains of magnetite, some of them arranged in branching aggregates of octahedra, also occur. The chemical analysis (No. 6 of Table 1) is distinctly quartz

monzonitic in character, with a marked sodic tendency—hence the name granodiorite rather than quartz monzonite, following Lindgren and Iddings.

"Basalt." Three specimens of basaltic lavas were studied by us, two of which proved to be olivine basalt and the third andesine andesite, using the nomenclature proposed by Iddings,¹⁸ and adopted by one of us for the Hawaiian rocks.¹⁹ According to this scheme, in the andesites the normative feldspars are dominant over the femic minerals, while in the basalts the amounts of each group are about equal. An andesite or a basalt may or may not contain modal olivine.

An *olivine basalt* from T'ang Shan, Ch'i Shia Hsien, Shantung, is black, densely aphanitic and wholly aphyric. The thin section shows rather numerous, small, equant, microphenocrysts of fresh olivine, in a very fine-grained groundmass, made up of grains of magnetite and smaller granules of colorless augite in a colorless glass base. Feldspar is almost wholly lacking and must be occult in the glass base. No analysis was made of this basalt. Basalts, of this and other kinds, would appear to be rather plentiful in the peninsula of Shantung, according to the descriptions by von Richthofen, Schwerdt, Rinne, and Blackwelder.

A basalt from Hsueh Hau Shan, Tsing Ching Hsien, Chihli, is medium gray, aphanitic and aphyric, with a few, small, irregular vesicles of the aa form. It is apparently not quite fresh, and was not analysed. Microphenocrysts of olivine are fewer than in the preceding specimen and they are all considerably altered to a yellow substance. The microgroundmass contains many small, thin laths of andesine, grains of magnetite, and granules and minute prismoids of colorless augite, in a colorless glass base. It is possible that this "basalt" is strictly an andesine andesite, as is that next to be described.

There is one specimen of "basalt" from Hai Ma Ho, Mongolia, a river which we cannot find on the maps available, but which is presumably near the Chihli border. Von Richthofen (pp. 381, 389, 739) states that in eastern Mongolia there are extensive flows of "basalt," which here, as in Shantung, are said to overlie "trachytes" and "rhyolites." Our specimen is medium gray, almost aphanitic, except for very small feldspar laths in a dense gray groundmass. There are numerous, small, irregularly angular cavities, which contain small tables of labradorite. The microtexture is intersertal, the rock being made up of rather thick, much twinned, plates of andesine,

¹⁸ IDTINGS, *Igneous Rocks*, 2: 21 1913.

¹⁹ WASHINGTON, *Amer Jour. Sci*, 5: 409. 1923.

about Ab_2An_3 , some small and altered, roundish grains of olivine, and fewer of fresh, pale gray augite. No magnetite grains are present, but there is considerable interstitial, dusty, brownish glass. The chemical analysis (No. 7 of Table 1) is that of an andesite, rather than of a basalt, in the usual acceptance of the terms. Its norm shows some excess SiO_2 , as is true of many such rocks, in spite of the modal presence of olivine, which belongs presumably to an early stage of crystallization, in accord with the so-called Bowen-Andersen effect.²⁰

Syenite area of Shansi. At Tzu Chin Shan, in western Shansi, Lat. $38^\circ 14'$ N. and Lon. $110^\circ 51'$ E., is an area of syenitic rocks, which have been described by Norin,²¹ who, however, gives no analyses of them. The igneous body is regarded by Norin as a laccolith. The igneous rocks are: "trachy-andesite" (phyric hornblende monzonite?), augite syenite, nephelite syenite, and aegirite-nephelite syenite, with tinguaitic dikes; a volcanic neck of brecciated syenite, cemented "trachyte," has broken through at one side. Our specimens are of augite syenite, nephelite syenite, and leucite tinguaitic.

The *augite syenite* is fine-grained, showing many small prismoids and grains of black pyroxene scattered through finely granular alkalic feldspar. The thin section shows that the texture is granitic, and that the rock is composed very largely of untwinned, slightly turbid, anorthoclase, with less, somewhat tabular, finely twinned albite or oligoclase-albite. There is very little nephelite, mostly as small rounded grains, included in the feldspars. The pyroxene forms subhedral prismoids, which are pale yellowish brown, with a slightly greenish tinge. It is faintly pleochroic, from pale olive green to pale greenish yellow, with extinction angles up to 40° , and apparently contains a small percentage of the acmite molecule. There are fewer small, rounded and mostly equant grains of a dark red, almost opaque, hornblende, some of which are included in the augite. In our specimen they are so opaque that little definite can be said of them, except that they are a sodic hornblende which closely resembles that which is present in the alaskite of Chihli. According to Norin, the hornblende is monoclinic, with an extinction angle of 10° – 12° , and he refers it to barkevikite, which, however, in our experience is usually much lighter in color and less reddish. Norin states that titanite "occurs abundantly," but none of this mineral was observed in our section, nor did we note any magnetite grains, which Norin mentions as also occurring. The chemical analysis of our specimen is given in

²⁰ BOWEN and ANDERSEN, Amer. Jour. Sci., **37**: 487. 1914.

²¹ NORIN, Bull. Geol. Surv. China, No. **3**: 45. 1921.

TABLE 2.—ROCKS OF SHANSI

	(1)	(2)	(3)	(4)	(5)	(6)
SiO ₂	55 38	56 40	53 75	50 00	51 93	52.91
Al ₂ O ₃	15 47	19 74	18 71	20 03	20 29	19 49
Fe ₂ O ₃	3 77	2 15	4 60	0 98	3 59	4 78
FeO	3 46	1 04	0 56	3 98	1 20	2 05
MgO	2 20	0 21	0 03	0 69	0 22	0 29
CaO	6 65	2 93	1 11	3 41	1 65	2 47
Na ₂ O	4 77	2 75	5 43	8 28	8 49	7 18
K ₂ O	5 11	12 42	12 64	8 44	9 81	7 88
H ₂ O+	0 36	0 33	0 78	1 50	0 99	1 19
H ₂ O-	0 03	0 28	0 07	0 10	0 10	n. d.
TiO ₂	1 96	1 52	1 61	0 99	0 20	none
P ₂ O ₅	0 36	0 14	none	0 21	0 06	trace
SO ₂	n. d.	n. d.	0 25	n. d.	0 67	n. d.
Cl	n. d.	n. d.	0 14	trace	0 70	0 53
MnO	0 11	0 08	0 13	0 50	trace	0 44
BaO	n. d.	n. d.	0 01	none	0 09	n. d.
	99 63	99 99	99 82*	99 87†	100 58‡	100.25§

Norms

	(1)	(2)	(3)	(4)	(5)	(6)
Or....	30 02	70 06	33 92	28 91	31 97	46 70
Ab	34 06	—	—	—	—	14 15
An	5 84	4 45	—	—	—	—
Le	—	2 62	31 83	16 13	20 28	—
Ne	3 41	12 78	13 02	30 39	26 98	22 72
Hl	—	—	0 23	—	1 17	0 82
Th	—	—	0 43	—	1 14	—
Ac	—	—	13 40	2 77	10 63	—
Na	—	—	0 49	2 56	0 12	—
Di	11 88	1 06	—	12 04	4 77	2 75
Wo	8 83	3 25	2 32	—	1 16	3 83
Ol	—	—	—	1 23	—	—
Mt.....	5 57	—	—	—	—	6 96
Il.....	3 80	2 13	1 52	1 82	0 46	—
Hm.....	—	2 15	—	—	—	—
Ru	—	0 40	0 80	—	—	—
Ap	1 01	0 34	—	0 67	—	—

(1) Augite syenite, II.5 (1)2 3*. Tzu Chin Shan, Lin Hsien, Shansi. KEYES analyst.

(2) Nephelite syenite, I(II) 6 1' 2 Tzu Chin Shan, Lin Hsien, Shansi. KEYES analyst.

(3) Pseudoleucite tinguaitite, II.7 1 2. Tzu Chin Shan, Lin Hsien, Shansi. KEYES analyst.

(4) Pseudoleucite tinguaitite, II 7(8) 1 3. Beemerville, New Jersey. WOLFF analyst U. S. Geol. Surv. Prof. Paper 99, 577, 1917.

(5) Pseudoleucite tinguaitite, II 7(8).1.3. Bearpaw Mts, Montana. STOKES analyst U. S. Geol. Surv. Prof. Paper 99, 577, 1917.

(6) Pseudoleucite tinguaitite, (I)II.6.1 3(4). Magnet cove, Arkansas. WILLIAMS analyst. U. S. Geol. Surv. Prof. Paper 99, 553, 1917.

* Includes ZrO₂ none, Cr₂O₃ none.† Includes CO₂ 0 22, FeS₂ 0 54‡ Includes CO₂ 0 25, F 0 27, SrO 0 07.

§ Includes S 0 52, X 0 48, SrO 0 09

No. 1 of Table 2. Some of the normative ilmenite presumably exists in the sodic hornblende, which is usually rather high in titanium.

The *nephelite syenite* of the area is regarded by Norin as intermediate between the augite syenite and the aegirite-nephelite syenite. According to him, the nephelite syenite is very variable in character, both texturally and modally, and he thinks that these syenites are schlieren-like "differentiation products from the augite syenite magma." Our specimen appears to differ from what Norin describes as "a representative type." It is pale gray and somewhat phyrlic, showing thick-tabular phenocrysts of alkali feldspar, in a medium-grained, granitic-textured base, composed of gray feldspar, some flesh-colored nephelite, irregular spots of a black mineral with sub-metallic luster, and a few small scales of biotite. The thin section shows no features of special interest as regards the feldspar, which is a slightly turbid anorthoclase, and the much less abundant nephelite, the latter being fresh. None of the pyroxene, mentioned by Norin, appears in our sections, but there is a little brown biotite. Norin mentions that biotite is abundant when pyroxene is subordinate and vice versa. The megascopically black areas resolve themselves, in thin section, into clusters of small grains of a yellow-brown, isotropic mineral, with high refractive index; this is evidently the spinel spoken of by Norin. We could detect no titanite, which Norin says is abundant. The results of the chemical analysis of our specimen are shown in No. 2 of Table 2. This is remarkable for the high content in alkalis, especially in potash; giving rise to a small amount of normative leucite, which is taken up by the modal nephelite. The subrang, I.6.1.2, in which the rock falls, is as yet unrepresented by any analysis, so that this subrang, I.6.1.2, may be named *shansose*.

As we have no specimens of the aegirite syenite or of the "trachy-andesite," the reader is referred to Norin's paper for descriptions of them.

Pseudoleucite tinguaita. Our specimen of this, the only representative of the many kinds of (mostly tinguaitic) dikes in the area, belongs to Norin's first type of "leucite tinguaita porphyry." It shows rounded or sub-angular phenocrysts of pseudoleucite, up to 1.5 cm. in diameter, in a greenish black, densely aphanitic ground-mass. It can be seen by the naked eye that the pseudoleucites are composed of two minerals, a finely granular, grayish white feldspar, and pale flesh-colored nephelite, the latter occurring mostly in the interior of the crystal aggregate. Under the microscope, the large pseudoleucites show the usual aggregate of orthoclase and rather

less nephelite grains. No leucite could be detected, although Norin notes the presence in his specimens of a clear, colorless, isotropic mineral, with low refractive index, which he thinks is analcite, but which may be leucite. In the pseudoleucites are needles of aegirite and a few bundles of slender needles of natrolite. The holocrystalline groundmass is made up of very small anhedral grains of orthoclase and nephelite, irregularly sprinkled with very slender needles of aegirite, which are so thin that the individuals appear to be black, although the more crowded, felt-like areas show a greenish tinge. No sodic hornblende was seen nor was there found any of the sodalite group of minerals, although the chemical analysis indicates that very small amounts of some of these are present, as they are in other pseudoleucite tinguaites.

The chemical analysis (No. 3 of Table 2) shows about the same very high percentage of K_2O as does the nephelite syenite, but with less SiO_2 and twice as much Na_2O . As there is no, or at most very little, modal leucite, the normative leucite is to be considered as split up, forming modal orthoclase and potassic nephelite, in accordance with Bowen's interpretation of the composition of nephelite, based on laboratory study of the end members.²² The high Fe_2O_3 is connected with the abundant aegirite, into which enters also the small amount of sodium metasilicate shown in the norm.

The Chinese rock closely resembles, modally and texturally, the pseudoleucite tinguaites of Bear Paw Mountains, Montana,²³ and of Beemerville, New Jersey.²⁴ The analyses of these two (Nos. 4 and 5 of Table 2) are much like that of the Chinese rock, except for the higher K_2O and lower Na_2O of the last. All three are also alike in that their norms show notable amounts of the leucite molecule, although no modal leucite is discernible in thin sections. The Chinese tinguaitite falls in the subrang II.7.1.2, while the other two are in II.7.1.3. All three have a little sodium metasilicate in the norm. It may be recalled that both Pirsson and Wolff were cognizant of this excess of Na_2O over that needed for albite, nephelite, and acmite. Pirsson attributed this, in great part, to sodalite and nosean, which are present in the rock; but Wolff found difficulty in explaining it, as the New Jersey rock contains no sodalite, so that he somewhat doubtfully assigned it to aegirite. The pseudoleucite tinguaitite of Magnet Cove²⁵ is also similar to these three modally and

²² BOWEN, Amer. Jour. Sci., 43: 115. 1917.

²³ WEED and PIRSSON, Amer. Jour. Sci., 2: 194. 1896.

²⁴ WOLFF, Bull. Mus. Comp. Zool., 38: 273. 1902.

²⁵ J. F. WILLIAMS, Ann. Rep. Geol. Surv. Arkansas, 2: 267. 1891.

texturally, but its analysis (No. 6 of Table 2) shows slightly higher SiO_2 and lower Na_2O and K_2O , so that the norm contains none of the leucite molecule, and no leucite is present in the rock. All the known pseudoleucite tinguaites are connected with nephelite syenite and similar rocks, some of which they much resemble chemically, as the Chinese tinguaites resembles the accompanying nephelite syenite.

Summary. The specimens at our command are too few to give a very satisfactory idea of the general characters of the magma underlying eastern China, but the results of their study, taken in connection with the descriptions by others, allow us to form a general notion. The igneous rocks of the region are mostly granitic and granodioritic, true dioritic and gabbroic rocks being rare, and syenitic rocks even rarer. The common occurrence of effusive basalt, much of it with andesine, and of andesite (the "trachyte" of Richthofen and others), with some rhyolite, and the apparent absence of alkalic trachyte, phonolite, and tephritic lavas, also indicates that the general magma is decidedly silicic and of distinctly medium composition. Although many of the plutonic rocks have a decidedly sodic cast, yet the occurrence of nephelite syenite and other such very sodic rocks appears to be exceptional; they being known only in Shansi and in southern China, as has been noted by L  vy and Lacroix. In connection with this latter occurrence it may be noted that the jadeite of Upper Burma is regarded by Bleek²⁶ as a metamorphosed nephelite syenite, as was suggested earlier by Pirsson²⁷ for the jadeite of Tibet.

ETHNOLOGY.—*Piscataway royalty: a study in stone age government and inheritance rulings.*¹ W. C. MACLEOD, Wharton School, University of Pennsylvania. (Communicated by JOHN R. SWANTON.)

1. THE PISCATAWAY OVERLORDSHIP

The Piscataway were an Algonkian tribe or nation whose village was located originally in Maryland, at the junction of Tinker's and Piscataway Creeks, some fifteen miles south of the present city of Washington. The name Piscataway is also used to denominate the group of tribes, each with its own head chief or "king," over which the "king" of the Piscataway tribe ruled as overlord or "emperor." The Piscataway overlordship or "empire" embraced lands stretching for

²⁶ BLEEK, *Rec. Geol. Surv. India*, 36: 254 1907.

²⁷ PIRSSON, *Amer. Jour. Sci.*, (4), 1: 401. 1896.

¹ Received April 15, 1926.

130 miles from east to west in the Potomac River valley, north of the river; south of the river was the domain of Powhatan, "emperor" of the tidewater Virginia tribes.² About 1634 under the Piscataway overlordship were the tribes—and their kings—called Chingwawataick, Nangemaick, Mattowomans, Potopaco, Sacayo, and Pangayo. An archival note of 1666 would indicate the inclusion, at least at that date, of the Mibibiwomans and Masquetend; and also, but certainly very doubtfully, of the Anacostia of the District of Columbia and the Nanticoke groups, the Choptico and Doags. The Anacostia in 1631 were noted as being under the protection of the tribes of the upper reaches of the Potomac River, and warring on the Potomac tribe; the "protectors" of the Potomac tribe were also warring on the Piscataway.³ But by 1666 there had been a serious decline in the native population, and some adjustment of sovereignties and alliances. By 1666, moreover, the same delegate, Mattabone, represented both the Piscataway tribe and the Sacayo tribe in conference with the English, which suggests that the Sacayo were losing their tribal identity; at this time the Pangayo and the Chingwawataick appear to have coalesced.

The Piscataway empire was clearly organized much after the pattern of that of Powhatan. Each tribe was constituted of a village and its suburbs or hamlets, under a tribal king who was subordinate to the king of the ranking tribe.

The Piscataway organization appears to have been no recent formation. In 1660 representatives of the component tribes explained for the benefit of the governor of the province or colony of Maryland in conference that their first emperor had come from the Eastern Shore of Maryland, historically Nanticoke country, thirteen generations before. That this first emperor had ruled over all the tribes or villages of what in 1660 was the colony of Maryland (the tidewater). They named "every town separately;" but the Proceedings of Council does not make record of the list. It is implied that then the Nanticokes were subject to the Piscataway emperor; and it is stated that in that day the historic enemies of the Piscataway,—the Potomac and the Susquehannock,—were subject to the Piscataway.⁴ This last statement we may imagine may be mere boast on the part of the Piscataway. Thirteen generations would carry the Piscataway genealogy back to perhaps 1540 A.D.

² See BRINTON, *Walam Olum*, pp. 226-227.

³ FLEET, pp. 25, 30, SMITH, *General History*, Book 4: 377, 378.

⁴ Council of December 20, 1660.

In 1639 the English Jesuits arrived in Maryland to missionize the Indians, under the patronage of Lord Baltimore. In that year they established a mission at the "metropolis of Piscataoe," the town of the Piscataway tribe; but in 1642, due to the war of aggression by the Susquehannocks, they had to move their station down river to Poto-paco. Father White was the head of the Jesuit mission. As we shall see it is likely that the missionaries had some influence in the politics of the natives. Further European influence came shortly when the Piscataway agreed with the colonial government that their native political offices should require ratification by the colonial governor in order to be valid.

2. MATRILINEAL INHERITANCE OF OFFICE

Piscataway inheritance appears to have been similar to that obtaining in Powhatan's empire south of the river.

Powhatan, emperor of the tidewater Virginia tribes, in the course of an address to John Smith, said that the heirs to his imperial office in order of preference according to native law were (1) his three brothers, (2) his two sisters, (3) the daughters of his two sisters. Apparently his two sisters had no sons, for John Smith writes that sisters' sons were preferred to sisters' daughters. Powhatan emphasized the fact that *primogeniture also was the rule*; an elder brother succeeded in preference to a younger brother; but preference was for male heirs, so that a younger brother would follow his elder brother before any sister of the brother could succeed. Our data on the Piscataway is not so explicit, but nevertheless indicates that exactly the same rulings held; and it furthermore shows us that *a sister's daughter, even though only a child, would be preferred in succession to chiefship before any cousin of the former incumbent*. These matrilineal, primogenitural rulings apparently were general among the tribes of the southeast of North America, and are *exactly* similar to the inheritance preferences prevalent among the mother-sib tribes of northwestern North America, save in the case perhaps of the Tahltan of the plateau who seem to have preferred male cousins to sister's daughters.⁵

⁵ SMITH, *Relation*, pp. 52, 115; and *Description*, p. 165. SMITH adds that office never descends to heirs of the brothers of the incumbent. Compare Anonymous, *A Relation of Maryland*, p. 84, 1635. MACLEOD, *Natches Political Evolution*; *Aspects of Northwest Coast Social Organisation*; and LAWSON, *Carolina*, p. 318. MORICE (p. 142) notes among the Carrier Indians of the Northwestern plateau, that if there are no brothers, sisters, or sisters' children to succeed to the chiefship, the nephew, or even the niece of the mother of the deceased, that is, a cousin on the mother's side, might succeed.

The first "emperor" of the Piscataway line, circa 1540 A.D., was succeeded by his brothers, in turn, and the last of these was succeeded by a sister's son of the eldest brother, "and so on, from brother to brother, and for want of such, to a sister's son," on down to the period of the arrival of the English circa 1600.⁶ The ruling sovereign when the English arrived was Kittamaqund. This emperor had slain his brother Wannas," to the end that he might enjoy the crown by the right of their succession, *brother always succeeding brother till they all be dead.*"⁷

Among the other tribes of the upper Chesapeake region and of the eastern shore we have a number of annotations referring to boy kings and emperors, with regents acting for them pending their maturity; and notes also of queens or female rulers.⁸

3. THE QUESTION OF THE SIB

We must now emphasize the fact that for the Piscataway (as for their neighbors) we have recorded *virtually no note of inheritance rulings save those applying to the office of king or civil head chief*, and that matrilineal inheritance of the chiefship is not in itself evidence for matrilineal inheritance of property, nor of the existence of the mother-sib. Among the Chitimacha of Louisiana it is found associated with the father-sib; and among the Yuchi who formerly dwelt on the plateau back of Virginia, it is associated with the mother-sib, but also with patrilineal societies; while among the Natchez it is associated with a form of patrilineal inheritance of rank.

The presence of matrilineal chiefship, however, indicates, in all likelihood, at least the influence of the mother-sib. The north-eastern Sioux of the Virginia highlands and plateau apparently possessed the mother-sib. Of these plateau peoples Lederer noted in 1671 that:

From four women, viz., Pash, Sepoy, Askarin, and Maraskarin, they derive the race of mankind; which they therefore divide into four tribes, distinguished under these several names. They very religiously observe the degrees of marriage, which they limit not to distance of kindred, but difference of tribes, which are continued in the issue of the females; now, for two of the same tribe to match, is abhorred as incest, and punished with great severity. Their places of burial they divide into four quarters, assigning to every tribe

⁶ Council of December 20, 1660.

⁷ Council of May, 1662; compare above

⁸ Compare, for example, WHITE, *Brief Relation*, p. 41; *Jesuit Letters*, pp. 124-125, 136; and above

one; for, to mingle their bodies, even when dead, they hold wicked and ominous.⁹

This is clearly an attempt by one not trained in ethnology to describe the mother-sib. To the northeastern and southeastern Siouan, the Algonkian of the tidewater were indebted for much of their material and social culture and it may be that the mother-sib had been borrowed.

4. HISTORICAL DATA ON THE PISCATAWAY DYNASTY

In 1640 the Piscataway emperor was Kittamaqund. In that year he and his family were converted to Catholicism by the Jesuits. In 1641 Kittamaqund died. Subsequently an Indian delegation to the English authorities stated that he had "died without brother or sister, and appointed his daughter to be queen." This daughter was a Catholic, one of two daughters of the deceased emperor; she was his favorite daughter. The Indians refused to assent to this breaking of the matrilineal rule of inheritance of office.¹⁰

From the time of this event, in the history of the first emperor to rule during the period of European influence, there appears to have been frequent irregularity in the inheritance of the office. To make this more comprehensible we will first outline something of the chronology, as it appears in the archival records.¹¹

⁹ The quotation is from LEDERER, p. 8.

On the inheritance of property we have a note by SPELMAN included in John Smith's compilations. The note very likely refers to Potomac River tribes. SPELMAN describes death and burial and then observes: "What goods the party leaveth is divided among his wives and children. But his house he giveth to the wife he liketh best, for life, after her death, unto what child he most loveth." This indicates patrilineal or bilateral property inheritance (ARBER's edition of SMITH, SPELMAN, p. CX).

On the possibility of the sib. An observer included in Smith's works noted for the Accohannock of the Eastern Shore that "In their marriages, they observe a large distance, as well in affinity as consanguinity." Properly affinity refers to relationship by marriage, but an observer without understanding of the sib may have misunderstood sib relationship for affinity. (SMITH, *General History*, p. 355.)

On the "significance of matrilineal chiefship" see MACLEOD, *Chiefship*, 1923. On the significance of Lederer's note for the sociology of the Sioux of the Plains compare SWANTON, *New Light*. On the general cultural relationships of eastern Siouan groups and the eastern Algonkian see SVECK, *Ethnological Position*.

¹⁰ Council of May, 1662; and *Letters of the Jesuits*, p. 126. In these letters, surprisingly enough, for the year 1641 we read of this daughter as "the young empress" (pp. 132, 135-136), and it is in these also that we read of the wife and two sons of "the Tayac," Tayac being the native term for emperor, and referring to Kittamaqund, very likely.

¹¹ The extermination of family lines by disease was no doubt disturbing inheritance at this period (compare MACLEOD, *Chiefship*, p. 467). Still, we read, (Council of December 20, 1660) that the first emperor was succeeded by his brother "since he died without issue." This "since" however is very clearly a misunderstanding on the part of the interpreter. (My italics.)

1. UTTAPOINGASSENEM:¹³ the first emperor, *circa* 1540 A.D.
2. QUOKENASSUM: brother of the foregoing, *circa* 1550 A.D.
Eleven unrecorded emperors follow, then:
14. KITTAMAQUND: . . . *died, 1641.* This emperor had slain his elder brother Wannas, (also spelled Uwamno) in order to secure himself the throne. Kittamaquond died without "lawful heirs,"—that is, brother, sister, or sisters' children. He wanted his daughter to succeed him, but the tribe refused this. Instead they chose as his successor¹⁴
15. WEGHUCASSO: (spelled also Wahocasso, and Walmcasso), who was a descendant of one of the brothers of the first emperor, Uttapoingassenem, who had succeeded to Uttapoingassenem's office. Weghucasso *died in 1658.*¹⁵ He was apparently himself without heirs for he was succeeded by another
16. UTTAPOINGASSENEM: . another descendant of one of the ancient emperors. This Uttapoingassenem *died in 1662,*¹⁶ after a short reign of four years. He was succeeded by
17. WANNASAPAPIN: . . . who is reported as the son of the Wannas who should have succeeded before Kittamaquond but who was slain by his brother, who succeeded instead. Wannasapapin died within one year, *in 1663.*¹⁶ He was succeeded by
18. NATTOWASSO: . . . who was the son of Weghucasso (no. 15, above); Nattowasso changed his name and took that of his father, Weghucasso. Nattowasso *died circa 1670.*¹⁷

The Weghucasso, who succeeded Kittamaquond, the native councillors told the governor of Maryland, was descended "from one of the brothers of the first emperor, which one, they knew not." Upon his death, Weghucasso "appointed" another "descendant of one of the first kings" to succeed himself.¹⁸ This is rather puzzling; suc-

¹³ Council of May, 1662, and *Jesuit Letters*, p. 123, and references cited above.

He was called Uttapoingassenem "inasmuch as he did, as it were, embrace and cover them all," that is, rule over all the tribes of Maryland. See Council of December 20, 1660.

¹⁴ Councils of December 20, 1660, and May, 1662, p. 45.

¹⁵ Council of February, 1658.

¹⁶ Council of May, 1662.

¹⁷ Council of June, 1663.

¹⁸ Councils of May, 1662, and of June, 1670, p. 289.

¹⁹ Councils of December 20, 1660, and of May, 1662, p. 453.

The title for king among the Piscataway we do not know; the title for emperor was Tayac, cognate with Nanticoke Tallak, head chief. In the 1660 council we read concerning Uttapoingassenem II, successor to Weghucasso, that he was to be called Jan Jan Wizous, "which, in their language, signifies a true king, and [they] would not suffer us to call him Towzin, which is the style [title] they give to the sons of their kings;" and the narrative continues to explain that sons may never inherit their father's office

cession to office by descendants of the deceased encumbant's brothers is not matrilineal. And succession by Weghucasso's son and by Wannas' son, is frankly patrilineal, just as was the succession of himself by his daughter determined on by Weghucasso's predecessor, Kittamaqund.

5. A PUZZLING ROYAL WEDDING

In the case of Nattowasso a puzzling situation is presented which, if it is ever wholly unravelled, will no doubt serve to illuminate social organisation in this region.

Nattowasso was a mere boy, eleven years old, when he succeeded. He died when he was about eighteen. Remembering Kittamaqund's killing of his brother, and the short one-year reign of Wannasapapin, son of the murdered Wannas and predecessor of the son of Weghucasso, we may suspect a quarrel for the office of emperor, especially so in view of the fact that on ratifying the Indian's choice of their boy emperor the colonial governor significantly then charged the Indians that they should not presume to wrong him upon any pretense either by poisoning of him or by other indirect ways.¹⁹ This may be compared with the note by Lawson for the Carolinas, that a chief's heirs were his sister's sons; but that occasionally a ruler would disapprove of his heir apparent; therefore: "Sometimes they poison the heir to make way for another, which is not seldom done, when they do not approve of the youth that is to succeed them. The king himself is generally the chief doctor in this cure."²⁰

In explaining their choice of Nattowasso, and of a further desire of heirs, the Indians said that:

In times past there were two families living at Piscataway, out of which two families their kings were chosen; the one being the family of Wannys, the other the family of Wahocasso, of which Wahocasso this Nattowasso descended, he being his eldest son as aforesaid. Further, the Indians show that there is a daughter of the family of Wannys now living at Piscataway, and about the same age as this youth now elected by them.²¹

Does the use of Towzin indicate something of the Natches plan of giving a certain rank to the sons of kings? (On Tayac as the term for "emperor" as distinct from mere "king," see *Jesuit Letters*, p. 125, and *A Relation of Maryland*, 1635, p. 84.)

Since we have, as to inheritance rules, compared the Southeast to the Northwest, we may note something in the Northwest comparable to this giving of title to sons of a chief in a matrilineal order. MORICE says of the "Toenezas," or chiefs of the Carrier Indians, whose office descended matrilineally, that "their rank . . . was shared in by their children, who were called "oeskezaz"—MORICE, p. 142. (My italics)

¹⁹ Council of June, 1663, p. 481.

²⁰ LAWSON: *Carolinas*, p. 318.

²¹ Council of June, 1663, p. 481

They state that they intend to marry these two child representatives of the two regal families, that of Wannas and that of Weghucasso; the boy, a son of a former emperor in the matrilineal line, to the girl, who is apparently a sister of the last emperor, Wannasapapin; the marriage is to be consummated as soon as the children are of "mature years." They also explain here that they intend to change the name of Nattowasso to Weghucasso, "after his father's name." The governor postponed his decision "concerning the uniting of these two families."

At the council in which eventually, seven years later, we hear of the death of the boy emperor, Nattowasso, we hear, incidentally, facts which indicate clearly that the king of Nanjemaick has been succeeded by his own son, one Necutahainon, suggesting that inheritance was tending toward the patrilineal even among the kingly offices of the tribes, as well as in the office of overlord or emperor.

NOTES ON SYNONYMY

NANGEMAICK appears sometimes as Nangemy, and Nangensaick; ANACOSTIA, as Analostan, Anacostaub, Nacostanck, Nacochtank, Nacostines, and Nazatica; SACAYO, as Zachaiah; POTOPACO, as Portobacco, Portobackes; CHINGWAWATAICK, as Chingwaters, Chingwawaters, Chingweatyke; PISCATAWAY, as Pascatoe. The PISCATAWAY were also known by a name of different root, spelled or transliterated variously as Ganawagas, Ganaweeses, Kanawhas, and Conoys.

In early days under the emperor Kittamaqund the Piscataway village was, by the English, called, after him, Kittamaqundi. At the same time the emperor's name was sometimes spelled by some of the English, Chitomachen. Chitomachen and Kittamaqundi are the same Algonkian name transliterated differently. Brinton thought erroneously that Chitomachen was a personal name, the name of the emperor, and Kittamaqund was a place name, the name of the Piscataway capital. Translating the two names into English, after "discovering" the Algonkian roots behind them, he got two remarkably different translations! This is a warning against reckless translation of Algonkian words which have been hopelessly corrupted in English transliteration; local historical enthusiasts should take notice.

WORKS REFERRED TO

- BRINTON, D. G., *The Walum Olum: or The Lenape and Their Legends*, 1883.
 FLEET, *Journal*, 1631; reprinted in NEILL, E. D., *Founders of Maryland*, 1876.
 HILTON, *Relation of Florida*; reprinted in FORDE, *Tracts*, vol. 4.
 LAWSON, JOHN, *History of Carolina*, 1714, reprinted 1860.
 LEDERER, JOHN, *Narrative*, 1671; English translation and reprint, 1900. (Reprinted also in ALVORD and BIDGOOD, *Trans-Allegheny Explorations*.)
Letters of the Jesuits, see under *Relation*.
 MACLEOD, W. C., *On the Significance of Matrilineal Chiefship*, *American Anthropologist*, 1923. *Natches Political Evolution*, *Ibid*, 1924. *Certain Aspects of Northwest Coast and of Algonkian Social Organization*, 1924 *Proceedings of the International Congresses of Americanists*.

- MOONEY, J., *Indian Tribes of the District of Columbia*, American Anthropologist, 1889
- MOORE, FR. A. G., *The Western Déné*, 1888-1889 Proceedings of the Canadian Institute. *Proceedings of Council*, Archives of Maryland.
- PROUDFIT, S. V., *Ancient Village Sites and Aboriginal Workshops in the District of Columbia*, American Anthropologist, 1889.
- Relation of Maryland*, Anonymous, 1635; in *Original Narratives of Early American History: Maryland Letters of the Jesuits in Maryland*. Selections. in Ibid.
- FR. A. WHITE: *Relatio Itineris*, Translation in Ibid
- SPACK, F. G., *Ethnological Position of the Southeastern Algonkian*, American Anthropologist, 1923.
- SWANTON, J. R., *New Light on the Early History of the Siouan Peoples*, Proceedings of the Washington Academy of Sciences, 1923
- WHITE, see Relation, etc

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

686TH MEETING

The 686th meeting of the Biological Society was held at the Cosmos Club January 16, 1926 at 8 p.m., with President OBERHOLSER in the chair and 103 persons present. The President announced the membership of the following committees: *Committee on Publications*, C. W. RICHMOND, CHAIRMAN, J. H. RILEY, G. S. MILLER, JR.; *Committee on Communications*, W. R. MAXON, CHAIRMAN, S. A. ROHWER, V. BAILEY. The President referred to the recent death of W. E. SAFFORD and to his many services to the Society.

O. J. MURIE, Biological Survey. *On the trail of the big brown bear in Alaska.*—Two species of bear, *Ursus gyas* and *Ursus kidderi*, inhabit the Alaska Peninsula throughout its length and are also plentiful on Unimak Island, which is separated from the mainland by a narrow strait. *Ursus gyas* is probably the largest of the brown bears, with the possible exception of the form on Kodiak Island. Hence this is the largest carnivorous mammal in the world. The Aleutian Range, which follows closely the Pacific side of the Peninsula, is the natural home of this bear, the lava beds and other rugged portions of the mountains furnishing ideal retreats for hibernation in the winter. The bears emerge from winter quarters probably in the latter part of April or the first part of May and spend the spring season high in the mountains, where they feed largely on grass, roots, and ground squirrels. They appear to prefer the lofty ledges and snow patches on which to lie and doze during the day. Late in June they begin to go to the lowlands and in July are found congregated about the salmon streams where these fish are coming up to spawn. During the summer the salmon form an important item on their bill of fare. In going to and from favorite feeding places the bears have worn deep trails across the tundra and over the marshes. These are interesting indications of the presence of the bears and are often used by travelers. (*Author's abstract.*)—The subject was discussed by C. H. MERRIAM, who mentioned Dr. T. H. BEAN's experience with these bears in Alaska; also by C. W. STILES, who spoke of a form of pernicious anaemia occurring in man from the eating of salmon. A very similar disease is found in the bear, and it is possible that the bear acts as a reservoir for the germs of this disease.

C. E. CHAMBLISS, Bureau of Plant Industry: *An unused southern wild food plant.*—There is a large acreage of wild rice (*Zizania palustris*) on the Atlantic Coastal Plain which supplies food for millions of wild ducks and many other marsh-loving birds. In this area this grass grows on the mud flats and low marsh land that border the tidal streams above brackish water. The seed of this plant should be gathered by the seedsmen of these southern States to supply the needs of the southern hunter, who at present can obtain seed only of the northern species of wild rice (*Zizania aquatica*). The hunter buys this seed at 80 cents per pound to sow in localities remote from tidal marshes to attract wild ducks and to supply them with one of their favorite foods. The northern species matures too early in the southern States to serve as shelter for game birds, and in this section it is also less productive than the southern species.

Besides supplying food for our game birds, this southern wild plant should also be used as a source of food for man. The aborigines of the Coastal Plain of the South Atlantic States probably never used this plant, or the value of wild rice seed as a food would have been brought to the attention of the early explorers to this coast, as it was to the first Europeans who went into the region of the upper Mississippi Valley. Here the white man found that among certain Indian tribes the seed of *Zizania aquatica* was one of the principal articles of diet. We are today indebted to the descendants of these Indians for the nutritious and very palatable parched wild rice that is obtainable from our leading grocers and for the seed that is sought by hunters in every section of the United States. (*Author's abstract.*)

J. W. GIDLEY, National Museum: *Fossil man associated with the mammoth in Florida: New evidence of the antiquity of man in America.*—The published reviews and opinions expressed by various authorities regarding the discoveries, a few years ago near Vero, Florida, reported by Dr. E. H. SELLARDS, were reviewed. These show a wide difference of opinion between the anthropologists and paleontologists regarding the contemporaneity of early man with a Pleistocene fauna in Florida, the former believing that the association of material as reported by Sellards is an unnatural one. Discoveries near Melbourne, about 40 miles north of Vero, made by the Amherst-Smithsonian Expedition of last summer seem to refute this, and to confirm in general Sellard's views regarding the general geology of the region and of the association of remains of man with those of a Pleistocene fauna, which he considered a natural one. Three important localities were examined in the Melbourne district, all showing similar conditions of deposition and geologic position. The Vero district was also revisited. The general conclusions reached as a result of the Amherst-Smithsonian Expedition are that the human remains located belong to the geologic levels in which they were found, and are not the result of later inclusions from the surface through human burials or otherwise; that the human bones and artifacts represent a people contemporaneous with the mammoths and mastodons with whose remains they were found associated, but that the general geologic conditions as interpreted suggest a relatively recent date, either late Pleistocene or even post-Pleistocene, for the extinction of the last survivor of the Pleistocene fauna in the south. (*Author's abstract.*)—The subject was discussed by N. M. JENN, who stated that the human remains described cannot be more than 2,000 years old, basing his remarks on the similarity existing between these remains and those known from the Mississippi Valley. C. H. MERRIAM considered that the evidence now available made it clear that man was in existence in Florida in the Pleistocene, or else that the mammoth and associated mammals lived on into the present age.

687TH MEETING

The 687th meeting was held at the Cosmos Club January 30, 1926 at 8:10 p.m., with President OBERHOLSER in the chair and 106 persons present. New members elected: W. H. BALL, H. L. STODDARD.

T. S. PALMER made an announcement of the Sixth International Ornithological Congress, to be held at Copenhagen May 24-29. This is the first held since 1910.

HERBERT W. BRANDT, Cleveland: *A naturalist in Alaska* (illustrated).—With representatives of the Biological Survey and the Field Museum, the speaker spent the spring of 1925 in Alaska in the study of the native birds and mammals. Leaving Nenana on March 21, they travelled 800 miles by dog team down the Yukon and established headquarters at Hooper Bay in late April, after 40 days' travel. The Esquimaux of that region are a very primitive race, having almost no contact with whites. Their clothing is made entirely from the skins of birds, and they subsist on fish, birds and eggs, and seal. They are very fond of tea and tobacco. They are very accurate observers of birds, and base their names for them almost entirely on their calls and songs.

About the middle of May the snow began to disappear, and soon spring arrived, heralded by the geese. The first eggs (those of Western Sandpiper) were found on May 26, and soon birds were nesting freely. Birds were abundant, and all those collected were very fat. Many sing on the wing, but the song period is short, lasting only a week or 10 days. The different groups of birds observed—geese, ducks, sandpipers, plover, cranes, ptarmigan, jaegers, gulls, and others—were described and illustrated by colored slides. It was a "lemming year," and snowy owls remained to feed upon them and nest. They lay 6 to 9 eggs, at intervals of 2 or 3 days, and begin to incubate at once, so that the young in a nest present all stages of growth. The earliest nester is the Alaskan Jay, which lays from February to April, when the temperature is far below zero.

A. S. HITCHCOCK, Bureau of Plant Industry: *The grasses of Alaska: their distribution and relationship* (illustrated).—Alaska has four main physiographic areas: (1) The forested area of southeastern Alaska, which extends along the coast about to Kodiak Island, characterized by high rainfall and moderate temperatures; (2) interior Alaska including the valley of the Yukon and its tributaries west to the Yukon delta, characterized by sparse rainfall, extremes of temperature and rather open forests on the lower land; (3) the treeless region of west Alaska, including the Alaska Peninsula and the Aleutian Islands and most of the Seward Peninsula, consisting on the lower levels mostly of tundra; and (4) Arctic Alaska, including the drainage into the Arctic Ocean.

Many species of grasses have a wide distribution outside of Alaska. Several Arctic species are circumpolar; the species of southeast Alaska often extend south to the Puget Sound region; the species of the interior extend over Canada and southward in the Rocky Mountains. Several species found in the lowlands of Alaska extend southward in the mountains and in the United States are alpine plants. *Trisetum spicatum* is common near sea level in Alaska and the circumpolar area, but as an alpine plant extends southward in the mountains through North America into the high Andes, and finally in Terra del Fuego descends to the lowlands again; in the eastern hemisphere it extends south to the Himalayas, Tasmania, and the Antarctic regions. *Calamagrostis canadensis* is a common marsh species in the northern United States; in Alaska it is the dominant grass of the interior. As in all northern

countries the grasses are chiefly of the tribes *Festuceae*, *Agrostideae*, *Aveneae*, and *Hordeae*; while the great tribes *Paniceae*, *Andropogoneae*, and *Chlorideae* are not represented or scarcely so.

An anomalous case of distribution is shown by *Sphenopholis obtusata*, which is abundant around Tanana Hot Springs below Fairbanks. Here is an area of several acres where the soil is kept warm by numerous hot springs. At this spot are found many plants of regions far to the south and not otherwise known from Alaska. The nearest known locality for the grass mentioned, south British Columbia, is about 1500 miles to the southeast. (*Author's abstract.*)

688TH MEETING

The 688th regular meeting of the Biological Society was held at the Cosmos Club February 13, 1926 at 8:05 p.m., with President OBERHOLSER in the chair and 63 persons present. New member: F. A. VARRELMAN.

A. WETMORE reported that the long-eared owl which was common 30 or 40 years ago is now rare in this vicinity. In company with Messrs. McAtee and Preble, he found a dead bird near here about five years ago. A specimen collected in January of this year by E. B. Marshall of Laurel has recently been sent to the Museum. This bird collects in small bands in the winter, and is decidedly unsuspicious. Its growing scarcity is no doubt due to its being shot by hunters.

A. S. HITCHCOCK gave an account of the life of Aimé Bonpland, who accompanied HUMBOLDT on his South American and Mexican trip.

C. W. STILES and M. B. ORLEMAN, U. S. Public Health Service: *An attempt to untangle man and the higher apes.*—The nomenclature of Man, the African Chimpanzees, the Malayan Orang-utans, the Barbary Ape, and the Macaques, is an extremely confused status, not only in general literature but also (except for *Homo sapiens*) in that of systematic mammalogy, medical zoology, bacteriology, and public health. Specialists in mammalogy have referred the complications to the International Commission on Zoological Nomenclature for special action under "Suspension of the Rules," but the data submitted were not complete. The present article reviews the subject from 1551 to date, and the conclusion is reached that the premises present not only a very confused condition in systematic zoology but also one which potentially involves the loss of human life because of the danger of erroneous application of experimental data in bacteriological and serological literature.

According to our interpretation of the International Rules: (a) the correct specific name of the chimpanzee is *satyrus* Linn., 1758; (b) under one interpretation *Simia* 1758 is the correct generic name for the chimpanzee, while *Macaca* 1799 is the generic name for the Barbary ape, and *Silenus* 1820 is the generic name for the macaques (not including the Barbary ape); (c) under another interpretation, *Simia* 1758 should be used for the Barbary ape, while the chimpanzee should be known either as *Theranthropus* 1828 (a sale catalogue name) or as *Chimpanzee* 1831; (d) *Pongo pygmaeus* 1760 is the correct name for the Malayan orang-utan now usually known as *Simia satyrus*.

Obviously, the case must be reopened by the International Commission to decide between (b) and (c) at least.

The confusion of *Simia*, *Simia satyrus*, and *Pithecus*, is so extreme in systematic zoology and in medical publications that we despair of any outlook to make their use uniform and we are persuaded that zoologists should not assume the responsibility for what might result in bacteriological, serological, and public health work, if these cases are judged solely as questions

to be settled under the Law of Priority. We agree with specialists in mammalogy that an application of the rules will "produce greater confusion than uniformity," but we hold that the proposition advanced by the mammalogists would result in preserving ambiguous names and would not meet the desiderata for public health laboratories.

We offer an alternative proposition which appears to us to obviate all chances of ambiguity, namely, that (1-5) under the "Plenary Power" lodged in the International Commission—

1. The technical systematic names *Simia*, *Simia satyrus*, and *Pithecus* be declared suppressed and as eliminated from further use in connection with any genus or species in zoology;

2. *Theranthropus* 1828 be suppressed, because of inevitable difference of opinion as to its availability;

3. *Chimpansee* 1831 be adopted as official generic name for the African Chimpanzees, and the name be included in the "Official List."

4. The specific name *chimpansee* 1856 be declared type species of *Chimpansee* 1831,—thus giving a tautonymic combination similar to *Gorilla gorilla*.

5. The generic name *Macaca* 1799, type *inuus* = *sylvanus* 1758, be declared valid and be inserted in the Official List of Generic Names.

6. Finally, that the generic name *Pongo* 1799, type *borneo* = *pygmaeus* 1760, be inserted in the list of Official Names as correct name for the Malayan orang-utans under the Rules.

In analyzing the causes of the confusion in zoological nomenclature, the primary and most important factor, in our opinion, is the lack of proper instruction in the principles and practices of nomenclature (i.e., the Grammar of Science). Students too often have to flounder around amid a chaos of technical names without being told why these names are used or how to use them. The remedy consists in teaching the Grammar of Science to persons who later have to speak and write the Language of Science. (*Author's abstract.*)—Discussed by C. H. MERRIAM and T. S. PALMER.

E. R. KALMBACH, Biological Survey: *Blackbirds vs. rice in Louisiana.*—This paper reviews a season's work devoted to a study of an interesting problem in economic ornithology. Blackbirds, particularly *Agelaius phoeniceus* subsp. and *Megaquiscalus m. macrourus*, exact a more or less regular annual toll from the rice grower situated near the southern border of the rice area. This damage often becomes serious for farmers close to the coastal marshes, necessitating protective or control measures. Work carried out from the end of April to the end of September indicated that successful control work could not be carried out during that period of food abundance. Additional work is planned for March and April of this year when better results against the troublesome local race of blackbirds is expected. Migrants from the north, present on the Gulf Coast in great numbers during late fall and winter, do not enter so forcibly into the problem of rice damage, which is most pronounced during the "milk" and "dough" stages of the crop. (*Author's abstract.*)

689TH MEETING

The 689th meeting was held at the Cosmos Club on February 27, 1926 at 8:10 p.m., with President OBERHOLSER in the chair and 53 persons present. New members elected: STUART T. DANFORTH, F. C. HOTTES, PAUL H. OEHSE.

The Secretary read the report of the Committee on Constitution and By-

laws, to be acted on by the Society four weeks later. The report was discussed by the President.

C. W. GILMORE, National Museum: *Remarks on fossil tracks from the Grand Canyon* (illustrated).—The speaker described a trip to the Grand Canyon, Arizona, undertaken for the dual purpose of securing a collection of fossil tracks for the U. S. National Museum, and of preparing an exhibit of the tracks *in situ* for the National Park Service. The tracks occur in the Coconino sandstone (Permian), at a level more than 1,000 feet below the present rim of the Canyon wall, where the famous Hermit trail crosses the sandstone on its descent into Hermit Basin. Both of the above-mentioned projects were successfully carried out, a collection of slabs of footprints some 1,700 pounds in weight was secured for the National collections, and a track-covered area several hundred square feet in extent was uncovered by the side of the trail to form a permanent exhibit of the tracks as they occur in nature. It was pointed out that all of these tracks are found on the inclined surface which make up the strong cross-bedding of the sandstone, and that with one exception all of the hundreds of tracks and trails observed were headed up the slope. No satisfactory explanation of this fact has yet been obtained. It was pointed out that the Ichnite fauna of the Coconino sandstone as now known consists of 8 genera and 10 species, representing both vertebrate and invertebrate animals. All of the vertebrates were quadrupedal in gait, and all were relatively small, probably representing the two classes Reptilia and Amphibia. No skeletal remains have yet been found in the Coconino sandstone, consequently no direct evidence can be offered as to the makers of any of these tracks. (*Author's abstract.*)

Discussed by DAVID WHITE, who referred to the recent calculations of the age of the earth based on the rate of atomic disintegration of radio active minerals. According to these calculations, the age of Permian deposits is put at 450,000,000 to 600,000,000 years and of some Precambrian rocks at 1,500,000,000 years.

WALDO L. SCHMIDT, National Museum: *Collecting invertebrates in South America* (illustrated).—The speaker spent six months, from August, 1925, to January, 1926, in a field study of the South American crustacean fauna, under the Walter Rathbone Bacon Scholarship administered by the Smithsonian Institution. This bequest was made by the late Mrs. VIRGINIA PURDY BACON, of Detroit, in memory of her son to enable studies to be made of the fauna of countries other than the United States.

Nearly three months were spent collecting along the Brazilian coast, in the vicinity of Rio de Janeiro and southward. Stations were established at Santos, Ilha São Sebastião, where in company with Dr. H. LUEDERWALDT of the Museu Paulista at São Paulo, a most profitable ten days field work was spent, Paranaguá, São Francisco and Florianopolis. One trip was made inland to Castro, in the State of Paraná, for the purpose of obtaining specimens of a carcinological rarity, *Aeglea intermedia*, which here was found to occur in great abundance. Blumenau in the State of Santa Catharina, long the home of Fritz Mueller, was also visited. Here are yet to be found the "primitive" microscopes with which he made all of his wonderful microscopic observations. At the Museu Paulista, in São Paulo, their very considerable and valuable collection of unidentified crustacea was lent for further laboratory study in Washington. The collections of the Brazilian National Museum were examined while at Rio de Janeiro.

In Uruguay about seven weeks were spent, chiefly at Montevideo, and in trips with the steam trawlers working out of that port. Calls were made at

Puerto La Paloma, Maldonado, and Barro de Santa Lucia. At Montevideo, the Instituto de Pesca maintains a well equipped fisheries laboratory. The National Museum, in view of the wealth of that country, where the American dollar is at a discount, should have a new independent building instead of being housed in a portion of the Teatro Solis building.

At Buenos Aires the first year's field work was brought to conclusion with an examination of the extensive crustacean collections here brought together by the Buenos Aires Museum. Permission was granted to take a selected series back to Washington. The excellence of the collections of these forms is in a measure due to a system of subsidizing fishermen, and providing them with suitable collecting kits. A visit was also paid to the famous museum at La Plata where, in addition to their marvelous exhibit of fossil vertebrates, other zoological collections are maintained. Here too, the carcinological collections were most generously tendered for study in Washington. (*Author's abstract.*)

S. F. BLAKE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Dr. JOHANNES SCHMIDT, Director of the Carlsberg Physiological Laboratory will give an address under the joint auspices of the ACADEMY, the Smithsonian Institution, the Carnegie Institution, and the Biological Society at the National Museum on Friday, June 4, on the *Danish oceanographical expeditions: eel investigations*. The address will be illustrated by film and lantern slides.

At a meeting of the American Institute of Chemists, held in New York on May 8, Dr. WILLIAM BLUM of the Bureau of Standards was awarded the Institute's first annual medal for "Distinguished Service in Governmental Work." Dr. C. E. MUNROE made the presentation address. Dr. BLUM responded with an address on *Science for humanity's sake*.

Professor H. H. BARTLETT, Director of the Botanical Garden of the University of Michigan, visited the Grass Herbarium to identify some fragments of grasses and other economic plants excavated from Graeco-Roman sites in Egypt by Professor A. E. BOAK, of the University of Michigan. Professor BARTLETT has been appointed honorary collaborator of the Smithsonian Institution and will collect in Formosa and Sumatra on behalf of the two institutions mentioned.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 16

JUNE 19, 1926

No. 12

STATISTICS.—*The frequency distribution of scientific productivity.*

ALFRED J. LOTKA. Metropolitan Life Insurance Company, New York.

It would be of interest to determine, if possible, the part which men of different calibre contribute to the progress of science.

Considering first simple volume of production, a count was made of the number of names, in the decennial index of Chemical Abstracts 1907-1916, against which appeared 1, 2, 3 entries. Names of firms (e.g. Aktiengesellschaft, etc.) were omitted from reckoning, since they represent the output, not of a single individual, but of an unknown number of persons. The letters A and B of the alphabet only were covered. These were treated both separately and in the aggregate, with the results shown in the table and in figures 1 and 2 below.

A similar process was also applied to the name index of Auerbach's *Geschichtstafeln der Physik* (J. A. Barth, Leipzig, 1910) which cover the entire range of history up to and including the year 1900. In this case we obtain a measure not merely of volume of productivity, but account is taken, in some degree, also of quality, since only the outstanding contributions find a place in this little volume, with its 110 pages of tabular text. The figures and relations thus obtained are shown in the table and in figures 1 and 2.

On plotting the frequencies of persons having made 1, 2, 3 contributions, against these numbers 1, 2, 3 of contributions, both variables on a logarithmic scale, it is found that in each case the points are rather closely scattered about an essentially straight line having a slope of approximately two to one. The approach to this ratio is particularly close in the case of the data taken from Auerbach's

TABLE 1—FREQUENCY DISTRIBUTION OF SCIENTIFIC PRODUCTIVITY

NUMBER OF CONTRIBUTIONS n	NUMBER OF PERSONS MAKING STATED NUMBER OF CONTRIBUTIONS				PER CENT OF TOTAL					
	Chemical Abstracts			Auer- bach's tables entire alphabet	Chemical Abstracts			Auerbach's tables		
	Letter A	Letter B	A + B		Observed		Com- puted ¹	Obs- erved	Com- puted ¹	
					A	B	A + B	A + B	Entire alphabet	
Total	1,543	5,348	6,891	1,325						
1	890	3,101	3,991	784	57.68	57.98	57.92	56.69	59.17	60.79
2	230	829	1,059	204	14.91	15.50	15.37	15.32	15.40	15.20
3	111	382	493	127	7.19	7.14	7.15	7.12	9.58	6.75
4	58	229	287	50	3.76	4.28	4.16	4.14	3.77	3.80
5	41	143	184	33	2.66	2.67	2.67	2.72	2.49	2.43
6	42	89	131	28	2.72	1.66	1.90	1.92	2.11	1.69
7	20	93	113	19	1.30	1.74	1.64	1.44	1.43	1.24
8	24	61	85	19	1.56	1.14	1.23	1.12	1.43	0.95
9	21	43	64	6	1.36	0.80	0.93	0.90	0.45	0.75
10	15	50	65	7	0.97	0.93	0.94	0.73	0.53	0.61
11	9	32	41	6	0.58	0.60	0.59	0.61	0.45	0.50
12	11	36	47	7	0.71	0.67	0.68	0.52	0.53	0.42
13	6	26	32	4	0.39	0.49	0.46	0.45	0.30	0.36
14	7	21	28	4	0.45	0.39	0.41	0.39	0.30	0.31
15	3	18	21	5	0.19	0.34	0.30	0.34	0.38	0.27
16	4	20	24	3	0.26	0.37	0.35	0.30	0.23	0.24
17	4	14	18	3	0.26	0.26	0.26	0.27	0.23	0.21
18	5	14	19	1	0.32	0.26	0.28	0.24		
19	3	14	17	0	0.19	0.26	0.25	0.22		
20	6	8	14	0	0.39	0.15	0.20	0.20		
21	0	9	9	1	—	0.17	0.13	0.18		
22	2	9	11	3	0.13	0.17	0.16	0.17		
23	4	4	8	0	0.26	0.07	0.12	0.15		
24	4	4	8	3	0.26	0.07	0.12	0.14		
25	0	9	9	2	—	0.17	0.13	0.13		
26	3	6	9	0	0.19	0.11	0.13	0.12		
27	1	7	8	1	0.06	0.13	0.12	0.11		
28	2	8	10	0	0.13	0.15	0.15	0.11		
29	2	6	8	0	0.13	0.11	0.12	0.10		
30	2	5	7	1	0.13	0.09	0.10	0.09		
31	0	3	3	0	—	0.06	0.04			
32	0	3	3	0	—	0.06	0.04			
33	3	3	6	0	0.19	0.06	0.09			
34	1	3	4	1	0.06	0.06	0.06			
35	0	0	0	0	—	—	—			
36	0	1	1	0	—	0.02	0.01			
37	0	1	1	1	—	0.02	0.01			
38	1	3	4	0	0.06	0.06	0.06			
39	0	3	3	0	—	0.06	0.04			
40	1	1	2	0	0.06	0.02	0.03			
41	0	1	1	0	—	0.02	0.01			

TABLE 1—CONTINUED.

NUMBER OF CONTRIBUTIONS n	NUMBER OF PERSONS MAKING STATED NUMBER OF CONTRIBUTIONS				PER CENT OF TOTAL					
	Chemical Abstracts			Auerbach's tables entire alphabet	Chemical Abstracts			Auerbach's tables		
	Letter A	Letter B	A + B		Observed		Com- puted ¹	A + B	Observed	Computed ¹
					A	B			A + B	Entire alphabet
42	0	2	2	0	--	0 04	0 03			
43	0	0	0	0	--	--	--			
44	0	3	3	0	--	0 06	0 04			
45	0	4	4	0	--	0 07	0 06			
46	1	1	2	0	0 06	0 02	0 03			
47	0	3	3	0	--	0 06	0 04			
48	0	0	0	2	--	--	--			
49	0	1	1		--	0 02	0 01			
50	1	1	2		0 06	0 02	0 03			
51	0	1	1		--	0 02	0 01			
52	0	2	2		--	0 04	0 03			
53	0	2	2		--	0 04	0 03			
54	0	2	2		--	0 04	0 03			
55	2	1	3		0 13	0 02	0 04			
56	0	0	0		--	--	--			
57	0	1	1		--	0 02	0 01			
58	0	1	1		--	0 02	0 01			
59-60	0	0	0		--	--	--			
61	0	2	2		--	0 04	0 03			
62-65	0	0	0		--	--	--			
66	0	1	1		--	0 02	0 01			
67	0	0	0		--	--	--			
68	0	2	2		--	0 04	0 03			
69-72	0	0	0		--	--	--			
73	0	1	1		--	0 02	0 01			
74-77	0	0	0		--	--	--			
78	0	1	1		--	0 02	0 01			
79	0	0	0		--	--	--			
80	1	0	1		0 06	--	0 01			
81-83	0	0	0		--	--	--			
84	0	1	1		--	0 02	0 01			
85-94	0	0	0		--	--	--			
95	0	1	1		--	0 02	0 01			
96-106	0	0	0		--	--	--			
107	1	0	1		0 06	--	0 01			
108	0	0	0		--	--	--			
109	0	1	1		--	0 02	0 01			
110-113	0	0	0		--	--	--			
114	0	1	1		--	0 02	0 01			
115-345	0	0	0		--	--	--			
346	1	0	1		0 06	--	0 01			

¹ According to $f = 56.66/n^{1.288}$.² According to $f = 600/\pi^2 n^2$.

tables. Determined by least squares, the slope of the curve to Auerbach's data, as determined from the first 17 points,¹ was found to be 2.021 ± 0.017 . Similarly, the slope for the data in the Chemical Abstracts, letters A and B jointly, as determined from the first thirty points, came out as 1.888 ± 0.007 . The general formula for the relation thus found to exist between the frequency y of persons making x contributions is

$$x^n y = \text{const} \quad (1)$$

For the special case that $n = 2$ (inverse square law of scientific productivity) the value of the constant in (1) is found as follows:

$$y_1 = \frac{c}{1^2} \quad (2)$$

$$y_2 = \frac{c}{2^2} \quad (3)$$

$$y_n = \frac{c}{n^2} \quad (4)$$

$$\sum_1^n y = c \left(\frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \dots \right) \quad (5)$$

$$= c \sum_1^n \frac{1}{x^2} \quad (6)$$

$$= c \frac{\pi^2}{6} \quad (7)^2$$

$$c = \frac{6}{\pi^2} \sum_1^n y \quad (8)$$

But, since y is a frequency, the summation $\sum_1^n y$ gives unity.

Then finally

$$c = \frac{6}{\pi^2} \quad (9)$$

$$= \frac{6}{9.87} \quad (10)$$

$$= 0.6079 \text{ or } 60.79 \text{ per cent} \quad (11)$$

¹ Beyond this point fluctuations become excessive owing to the limited number of persons in the sample.

² See, for example, K. KNOPP, *Theorie und Anwendung der unendlichen Reihen*: 230, 1924 or J. L. COOLIDGE, *Mathematical Theory of Probability*: 22, 1925. For method of summation when exponent is fractional, see WHITTAKER and ROBINSON *Calculus of Observations*: 136, 1924. Exponent 1.888 thus gives the value $c = 0.5669$ appearing at the top of ninth column in Table 1.

Thus, according to the inverse square law, the proportion of all contributors who contribute a single item should be just over 60 per cent. In the cases here examined the actual proportion of this class to the whole was 59.2 per cent in Auerbach's data (1325 contributors), 57.7 per cent in the Chemical Abstracts under initial A (1543 contributors) 57.98 under letter B (5348 contributors) and 57.9 under letters A and B jointly (6891 contributors).

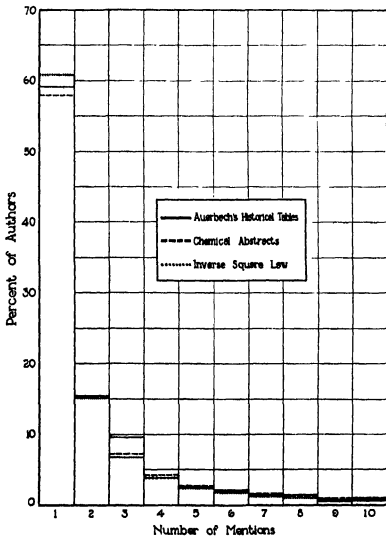


Fig. 1.—Frequency diagram showing per cent of authors mentioned once, twice, etc., in Auerbach's *Geschichtstafeln der Physik*, entire alphabet, and in the decennial index of Chemical Abstracts 1907-1916, letters A and B. The dotted line indicates frequencies computed according to the inverse square law.

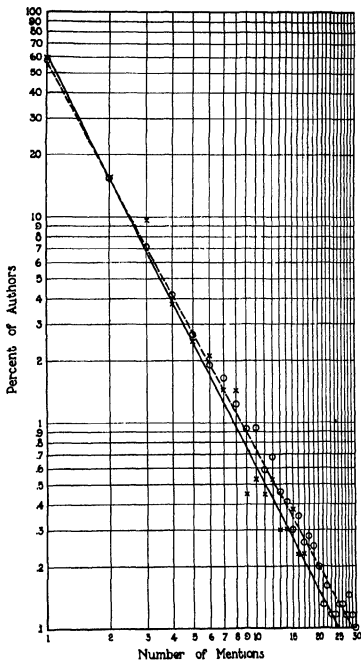


Fig 2 —Logarithmic frequency diagram showing number of authors mentioned once, twice, etc., in Auerbach's tables (points indicated by crosses), and in Chemical Abstracts, letters A and B (points indicated by circles). The fully drawn line indicates points given by inverse square law, exponent = 2; the line of dashes corresponds to exponent 1.89.

Frequency distributions of the general type (1) have a wide range of applicability to a variety of phenomena,³ and the mere form of such a distribution throws little or no light on the underlying physical relations.⁴ The fact that the exponent has, in the examples shown, approximately the value 2 enables us to state the result in the following simple form:

In the cases examined it is found that the number of persons making 2 contributions is about one-fourth of those making one; the number making 3 contributions is about one-ninth, etc.; the number making n contributions is about $\frac{1}{n^2}$ of those making one;⁵ and the proportion, of all contributors, that make a single contribution, is about 60 per cent.

The fact that two such widely different sources as Chemical Abstracts (listing practically all current work in chemistry over a ten year period) and Auerbach's tables (listing selected important contributions only, in physics, for all historical time) give very similar results, seems somewhat remarkable. It would be interesting to extend this study to such a work as Darmstaedter's *Handbuch der Geschichte der Naturwissenschaften und der Technik*. Unfortunately the index of this work does not indicate multiple entries of the same year under one author's name, but distinguishes only separately dated entries. It would therefore be necessary in each case to refer to the text. On the other hand the work could be abridged by restricting the inquiry to one or two letters of the alphabet, as was here done in the case of the Chemical Abstracts.

³ Compare especially CORRADO GINI, *Biblioteca dell' Economista*, ser. 5a, 20: *Indici di concentrazioni e di dipendenza*. See also the Report of Commission of Housing and Regional Planning, State of New York, Jan. 11, 1926: 59-73; and *Income in the United States*, by W. I. KING and others; 2: 344 et seq. 1922.

⁴ C. J. WILLIS' conclusions regarding the mechanism of evolution, inferred as they are from the occurrence of curves of this type in the relation between numbers of species and genera, seem for this reason to carry little conviction. See A. J. LOTKA, *Physical Biology*: 311. 1925.

⁵ Fortunately, however, there are somewhat more persons of very great productivity than would be expected under this simple law. The very high figures (e.g., Abderhalden, 346 contributions in ten years) should perhaps be considered separately, since they are not the product of one person unassisted. Joint contributions have in all cases been credited to the senior author only.

GEOLOGY.—*Geology of the Guantánamo Basin, Cuba.*¹ N. H. DARTON, U. S. Geological Survey.

During the Spring of 1916 I had the opportunity to examine the Guaso Valley and some of the surrounding ridges in the central part of Oriente District, Cuba, in the general vicinity of Guantánamo. The purpose of my visit was to ascertain the prospects for artesian water desired for irrigation by one of the large sugar companies and for this it was necessary to determine the stratigraphic succession and structure of the region. As there is nothing on record regarding these features and I also obtained some important paleontologic data it is believed that the results will be of interest. It was supposed that much of the area was covered by a tropical jungle but I found that exposures were extensive and while roads were not good, nearly all points could be reached easily on horse.

TOPOGRAPHY

As shown in the map, figure 1, the Guantánamo basin is a broad valley sloping to the south where it is flooded by tide water of the Bay of Guantánamo and the Enseñada de Joa. The valley heads to the north in a high ridge called Sierra Guaso and is bordered on the east by Sierra Maquay² and in part on the west, by Sierra Cañada. It is about 25 miles long and 15 miles wide. Much of the area is smooth or gently undulating but to the northward there are low terraced ridges between the shallow valleys of the streams. These streams head in the highlands to the north and northwest and flow south in nearly parallel courses to tide water. Guantánamo River, which rises far to the northwest, flows across the southeastern corner of the basin and empties into Guantánamo Bay near its mouth. The streams nearly all have steep banks 5 to 40 feet high, and most of them are deepening their channels into the rocks. But little alluvium is being deposited excepting in the bays and estuaries below tide water level.

THE ROCKS

General succession.—The oldest formation in the region consists of schists and other crystalline rocks which constitute the ridge on the sea shore at the Naval Station and the central and northern part of Sierra Guaso. I did not study these rocks but they appear to be simi-

¹ Received May 11, 1920.

² Named from shells and not from the Maguey plant.

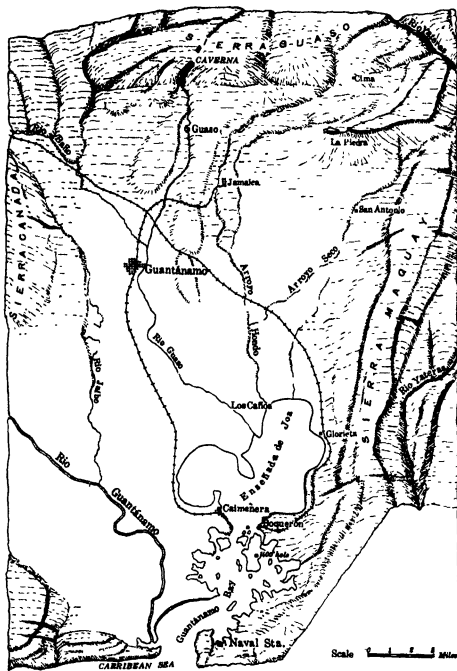


Fig. 1.—Sketch map of the Guantánamo region compiled from various sources, with additions by N. H. DARTON.

lar to those in the Santiago de Cuba region and in the ridge on the north side of the island. It seems possible that they may be of pre-

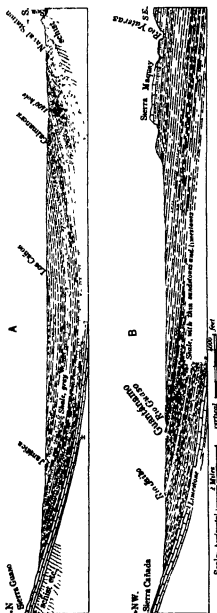


Fig. 2.—Sections across the Guantánamo region, Cuba. A, from north to south from Sierra Guaso to the Caribbean Sea. B, from west to east through Guantánamo.

Cambrian age but I have no evidence to offer on this point.

Sierra Guaso and Sierra Cañada consist of limestone of Eocene age, several hundred feet thick, apparently lying on the schists, etc. and dipping under the basin at a moderate angle as shown in the sections in figure 2. This limestone is overlain by 4000 feet or more of shale, in part sandy and including thin members of slabby sandstone, which underlies most of the Guantánamo basin. To the south at Caimanera and Boqueron this shale includes thick deposits of breccia and conglomerate, which appear to overlap to the south on the schists at the Naval Station.

The thick shale series grades up into a succession of limestones, sandstones, and shales, 1000 feet or more thick which constitute the Sierra Maquay, the high ridge north of San Antonio, and the mesa region on both sides of the valley of the Rio Yateras. The general relations of these formations are shown in figure 2. Terrace deposits of Quaternary

age occur in the Guantánamo basin and along the sea margin are terraces of coral, one very persistent one, the "Seboruco," extending to tide level.

The Guaso limestone.—The principal limestone of the region constitutes the cuesta of Sierra Guaso. The most notable exposure is at the mouth of the cavern through which the Rio Guaso comes out of the ridge where there is a canyon with vertical walls 150 feet high consisting of a practically continuous body of massive, light bluish-gray limestone. A few impure beds are included, and at the mouth of the cavern a few feet of underlying buff sandstone are exposed. The dip here and all along the ridge is to the south at a low angle. I traveled through the cavern and made a trip northward part way across the sierra, but did not have opportunity to go to the crystalline rocks, which I learned were in its higher central part. In a trip through Cima to Rio Yateras about 10 miles northeast of Jamaica, I passed along the slope of the Sierra Guaso and found that the river comes through it in a deep gorge. In the flats along the stream are great quantities of boulders of crystalline schists and intrusive rocks of many kinds, derived from the body which underlies the limestone.

I collected fossils from the Guaso limestone at several places, which have been determined by Cushman and Vaughan.¹ The following were obtained from strata high in the limestone succession on the slope of Sierra Guaso northeast of Guantánamo (Loc. 7666 USGS).

Conulites americana (Cushman)
Discocyclina cubensis (Cushman) Vaughan
Asteriacites subtaramellei (Cushman) Vaughan
Lepidocyclina subraulinii (Cushman)
Carpenteria proteus (Cushman)
Linderina sp.

According to Vaughan this fauna is "clearly Eocene, probably upper Eocene" a horizon which is widespread in Cuba and Haiti and apparently also present in Santo Domingo.

Guantánamo shale.—The thick series of shale underlying the Guantánamo basin undoubtedly overlies the Guaso limestone and grades up into the series of limestones, sandstones, and shales constituting Sierra Maquay. This shale outcrops extensively throughout the basin for there is but little cover of surficial deposits. There are high bluffs of it along the Rio Guaso in the eastern part of Guantánamo, and there are

¹ J. A. CUSHMAN, *Fossil foraminifera from the West Indies*: Carnegie Instn., Pub. 291. 21-71, pls. 1-15, 1919.

———, *The American species of Orthophragmina and Lepidocyclina*: U. S. Geol. Survey Prof. Paper 125: 39-105, pls. 7-35, 1920.

T. W. VAUGHAN, *American and European Tertiary larger foraminifera*: Geol. Soc. Amer. Bull. 35: 785-822, pls. 30-36, 1925.

many exposures of it along other streams. Apparently it extends far northwest up the Rio Bano Valley and westward, for I noted it along the railroad to San Luis, and to Jiguani where the underlying limestone comes up. Shale of the same character also outcrops at Antilla. The formation is well exposed in the wide flats about the Enseñada de Joa, notably near Glorieta and on the railroad cuts south of that place toward Boqueron.

The relations of this formation to the Guaso limestone were examined north of Guaso, near Cima, and at the foot of Sierra Cañada. At all of these places there is perfect conformity, but an abrupt change from limestone to shale. Superposition of the latter is evident throughout.



[Fig. 3.—Section from Sierra Guaso southeastward through La Piedra.

The thickness of the Guantánamo shale is about 4,000 feet, judging by width of outcrops and scattered dip determinations. In a section passing through Guantánamo, as shown in Section B, figure 2, the dips average from 6 to 10 degrees in the western part of the basin and about 5 degrees in the eastern part. Near Cima, however, where the dips are about 10 to 12 degrees, the thickness either is considerably less, some of the beds are cut off by a fault, or the base of the overlying formation begins at a lower horizon. The diminished thickness is shown in figure 3. The predominant material of the formation is brownish-gray shale in large part somewhat sandy and soft. Thin beds of brown to dirty gray sandstone occur at intervals, and thin beds of limestone appear at various horizons, especially near the middle of the formation. Some of the sandstone members are conspicuous in the town of Guantánamo and others at a lower horizon outcrop extensively on the east bank of the Rio Jaibo a few miles west of Guantánamo. A 10-foot bed of coarse arkose was noted 4 miles southeast of Guantánamo underlying fine-grained sandy limestone and underlain by dark shale with thin layers of limestone. The dip here is N. E. 70°. Other thin beds of limestone are conspicuous about Jamaica and in the bed of Rio Guaso in the northwestern part of Guantánamo.

In general the material of the formation becomes finer grained to the north. The clay of this shale is the cause of the very muddy condition of the basin during the rainy season when most of the roads become impassable for vehicles.

Some foraminifera were found in thin limestone lenses in the lower part of this formation at Cima northeast of Jamaica and in upper beds on the north slope of La Piedra. The latter were determined as follows by Cushman.⁴

Lepidocyclina schlumbergeri (Lemoine and Douvillé)
Lepidocyclina marginata (Michelotti)
Lepidocyclina sumatrensis (H. B. Brady)
Carpenteria americana (Cushman)

The specimen of *Lepidocyclina morgani* included in his list came from Jigue de la Argolla and Vaughan⁵ on reexamination of the collection believes that *L. marginata* and *L. sumatrensis* also came from other localities. Vaughan states that the name *L. dilatata* of Michelotti has priority over *L. schlumbergeri* and he finds that the genus is also represented in the collection by a new stellate species, soon to be described, and several other species. He adds to the list the following:

Orbulina? sp.
Globergerina sp.
Amphistegina sp.
Heterostegina sp.
and a coral
Orbicella imperatoris (Vaughan)

Vaughan states that this fauna is either Oligocene, probably high Oligocene, or very low Miocene. An Aquitanian age is not improbable. The coral *Orbicella imperatoris* indicates a high horizon. However, the fauna is a new one for the West Indies and it is probably for that reason that so few of the species can be identified.

Conglomerate of Boqueron and Caimanera.—The ridge and bluffs at Boqueron and Caimanera consist of a thick deposit of coarse dark conglomerate that appears to be in the midst of the shale series. The Boqueron ridge shows about 50 feet of the rock in thick irregular beds, most of it loosely cemented, and dipping S. E. at angles varying from 78° to 10°. Boulders from 1 to 3 inches in diameter predominate and they consist of quartzite and a considerable variety of diorites and other igneous rocks. Most of them are round, but some are angular

⁴ Op. cit., Prof. Paper 125.

⁵ Personal communication

and subangular. The following section shows the relations at this place.



Fig 4—Section of bluff at Boqueron on Guantánamo Bay, Cuba.

A bench or terrace on the west slope of the conglomerate ridge is occupied by an uplifted coral reef, but below this a dark sandy shale outcrops showing that the conglomerate is underlain by this material. Not far east of Boqueron are shales and sandstones which doubtless overlie the conglomerate and constitute the slopes of the west side of the southern extension of the Sierra Maquay. These shales are exposed in the deep railroad cuts along the bay shore between Boqueron and Glorieta.

The conglomerate in the bluff at Caimanera, across the bay from Boqueron, is similar to the rock at the latter place and apparently part of the same deposit. The beds here dip north at an angle of 8 degrees, with strike toward Boqueron. At one locality in the southern part of Caimanera the conglomerate is seen to be underlain by sandy shale as at Boqueron. Possibly the conglomerate extends under the low land to the west, but I did not have opportunity to trace it. It is my belief that the deposit marks the course of a stream which flowed across the region when the muds constituting the shale that now underlies the basin were being deposited.

A somewhat similar conglomerate was reported in a 1400-foot boring a mile and a half south of Boqueron sunk for water in 1906 at the first location of the U. S. Naval Station. The record was as follows: The first 141 feet was reported as mostly conglomerate some of which was termed "shale conglomerate" or "slate conglomerate." Next below are 300 feet of shales with several thin beds of conglomerate, some of which are reported as "sand conglomerate" and "lime conglomerate." Below 441 feet all was shale, of which the lower 90 feet were of lighter tint. A trace of coal was mentioned at 273 feet.

As the dip is to the east and northeast in this vicinity the beds in this hole doubtless underlie the conglomerate exposed at Boqueron and Caimanera. The relation to the strata in the region farther south is not known because the structure was not ascertained. Shale outcrops on the east side of Hospital Key, with dip S. 20°, and the rocks

about the U. S. Naval Station dip north, facts which indicate a shallow syncline to the south with a low anticline between Hospital Key and the 1400 foot boring.

Maquay formation: The prominent ridge known as Sierra Maquay consists of a succession of sandstones and limestones overlying the Guantánamo shale. These strata also constitute La Piedra and the ridge of which that feature is a part and they occupy a wide area in the high mesas and ridges east of Rio Yateras. There is considerable shale between the harder strata and apparently the succession of beds varies considerably from place to place. A basal member of about 40 feet of soft massive sandstone, with many hard layers 6 to 12 inches thick, appears in the lower slopes east of San Antonio and is well exposed in a railroad cut about one-half mile east of that plazita. Next above are softer sandstones with intercalated beds of shale and limestone which extend south along the western front of Sierra Maquay and northwestward to La Piedra toward which they rise on a low dip. On the trail passing through the gap in Sierra Maquay east of Glorieta I found 400 feet or more of the light-gray massive shales extending far up the slope to a thick cap of the gray slabby sandstones including thin beds of limestones, at the top of the ridge. These beds dip east at a low angle and constitute the cuesta that slopes down toward Rio Yateras. The valley of this fine stream is a deep one with high mesas of Maquay formation on its east side and it becomes a canyon a short distance south of the point at which the trail reaches it east of Glorieta.

At a locality called El Jigue de la Argolla about 2 miles northeast of San Antonio fossil echinoids, called "estrellas" by the people, have been obtained by Mr. Charles Ramsden of Guantánamo. Some of

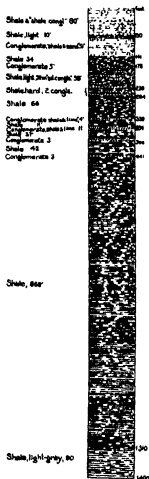


Fig. 5.—Record of deep boring 1 1/4 miles south of Boqueron, Cuba.

these kindly furnished by Mr. Ramsden have been determined as follows by Dr. Jackson:⁴

Echinolampas anguillae (Cotteau)
Clypeaster concavus (Cotteau)
Clypeaster placentoides, new species

The first two of these species were noted by Vaughan in Anguilla and they have also been reported from Antigua, in beds regarded as middle Oligocene and lower Miocene and while "the evidence is inconclusive"⁵ Vaughan is inclined to regard the echini at El Jigue de la Argolla as lower Miocene probably near the Anguilla horizon and the same as that on the north slope of La Piedra.

An echinoid obtained by Mr. Ramsden from Mount Toro, northwest of Guantánamo is a new species of *Clypeaster*. Another specimen collected by Mr. Ramsden from high on the slope of the valley of the Rio Yateras, 21 miles northeast of Guantánamo, has been described by Jackson as a new species *Cardiaster cubensis*, and for some unaccountable reason assigned to the Cretaceous.⁶ It is probable, however, that the strata at that locality are either upper Oligocene or lower Miocene.

STRUCTURE

Most of the data obtained as to structure of the region are set forth in the cross sections and the descriptions of the strata. The general structure is a wide syncline opening to the east. Various minor undulations were noted but their relations could not be worked out in the limited time at my disposal.

PETROLEUM

No traces of petroleum were observed. While the prospects are not encouraging, some of the sandstone members in the lower part of the 300 feet or more of the Guantánamo shale might possibly contain this material.

⁴ R. T. JACKSON, *Fossil Echini of the West Indies*: Carnegie Instn., Pub. 306, 1922.

⁵ Personal communication from manuscript in preparation.

⁶ R. T. JACKSON, *op. cit.*, pp. 5, 12, 69-70, G. STEFANINI, *Relations between American and European Tertiary Echinoid faunas*: Geol. Soc. Amer. Bull. 35: 845-846, 1923, questions this assignment to the Cretaceous and suggests that the age is Miocene.

ARTESIAN WATER

It seems unlikely that the sandstone members in the shale series under Guantánamo basin contain any large amount of water that would rise to or above the surface. These members are thin, mostly muddy and have very small outcrop areas but it is possible that in some places they might afford a local supply. It seems likely however, that there is some chance for water in the conglomerate near the Naval Station where the coarse deposits probably abut against the schists. It is also possible that if the 1400-foot hole south of Boqueron had been deeper it might have reached coarse beds containing water.

BOTANY.—*New species of cotton plants from Sonora and Sinaloa, Mexico.* O. F. COOK and J. W. HUBBARD, Bureau of Plant Industry.¹

A brief visit was made in December, 1925, to northwestern Mexico to study the native cottons and rubber-producing plants. In the vicinity of Guaymas two localities were visited where *Gossypium davidsonii* grew in abundance along dry washes and in open shrubby vegetation, much as *Thurberia* grows in Arizona. Also several forms of the native door-yard cottons were obtained at Guaymas and in the Yaqui Valley, at Esperanza, Cocorit, and Cajeme.

Most of the data regarding the native cottons were obtained at Los Mochis, Sinaloa, between San Blas and Topolobampo. Several of the native species had been collected and a small planting made at Los Mochis by Dr. W. W. Morrill, formerly State Entomologist of Arizona, and more recently engaged in agricultural investigations in Mexico. Dr. Morrill had observed a wide range of differences among the native cottons, and invited us to make a botanical study of the collection that he had grown at Los Mochis. Also he suggested that we stop at Guaymas and in the Yaqui Valley, to see the other types of native cottons that he had noted in those districts.

The classification of the species of *Gossypium* presents several difficulties that are not apparent on the surface, but are more appreciated as wider knowledge and experience are gained. One of the chief difficulties is that the cotton plants and their relatives have a protean flexibility of response to different conditions of growth. Such changes of characters often extend beyond any reasonable prospect of associating the members of the same progeny, if the origin of the seed is not

¹ Received May 5, 1926.

definitely known. The size of the plants, the habits of growth, the forms, textures and surfaces of the leaves and involucre bracts; the sizes and shapes of the bolls, numbers of locks, and even the seed and lint characters, have been profoundly altered in some of the cottons brought from tropical countries, when planted for the first time in the United States.

Other difficulties in classification arise from differences of age and of seasonal or cultural conditions, complicated also by the variability and diversity that are usually to be found in the leaves and other organs of the same individual plant. The juvenile leaves are different from the adult leaves, the stalk leaves different from the branch leaves, and the sun leaves different from the shade leaves. Thus a very wide range of sizes, forms and textures of leaves, bracts, and bolls, may be found on any large plant. Yet with side by side comparisons of living plants and judicious selection of material, it becomes possible to recognize and formulate contrasting characters. Without such comparisons the characters remain too indefinite and intangible to be used for purposes of diagnosis.

Much of the herbarium material of *Gossypium* has been assembled with no recognition or purpose of showing the distinctive characters of the species, and the association of such material into species is largely speculative or arbitrary. The usual herbarium specimen is a part of a fruiting branch with a flower, but showing little of the range of characters, even of the leaves and involucres. The characters of the fresh unopened bolls, which afford some of the most distinctive features, are difficult to preserve, and usually disappear in the dried specimens.

Finally, the task of classification is complicated by the wealth of plant types, whether species, varieties, or hybrids, of which it is necessary to take account. Missionaries and traders have carried cotton seed to remote regions, so that many of the primitive tribes have obtained commercial cottons which now are variously hybridized with the native kinds. In addition to the principal commercial species and their numerous varieties, there undoubtedly are hundreds, if not thousands, of appreciably different forms of cotton in cultivation among the primitive tropical peoples of both hemispheres.

The conditions of existence for cotton plants no doubt were profoundly changed during the agricultural period of human development, in prehistoric times. With the spread of the primitive agricultural people over the tropical world, the forest areas were restricted and the

species of cotton that previously had been isolated were brought together and allowed to hybridize.

From the fact that cotton is not tolerant of shade, it may be inferred that the species were limited in their natural distribution to dry districts where other vegetation was sparse and open, either because the soil was too rocky or too sandy, or because the rainfall was too limited or too irregular to support large trees or a dense growth of forest. There may have been many separate areas where different wild species of cotton existed, and a few may still exist under conditions of natural isolation, like other wild plants.

How many species there were, before the agricultural period, it may be impossible to determine, or to establish definitely the original associations of the characters. The recognition of species necessarily is provisional in our present state of knowledge, but at least the differences that exist should be recognized, and the out-standing peculiarities that appear in the cotton plants of different regions should be recorded, as affording the best prospect of associating the characters correctly.

Although most of the West-Mexican cottons are to be associated with Watt's Section IV on account of the smooth seed, other characters are remote from those of the Sea Island series. These differences include the presence of distinct angular teeth on the calyx, in some cases produced into slender points, that may even project beyond the buds.

Another departure from the Sea Island series is in the form of the leaves, with the auricles very large, the sinus often completely closed and the lobes overlapping. In these respects there may be more affinity with some of the species of Watt's Section III, species with fuzzy seed and free bracts. Yet these Mexican cottons may be associated with the Sea Island series in the broadest sense, since their seeds are fuzzy only at the base and their bracts are somewhat united.

KEY TO MEXICAN COTTONS

Outer nectaries located on the pedicel, below the receptacle, forming a narrow groove on a longitudinal ridge; large leaves of uprights with broad flat lobes, the margins often distinctly undulate

Gossypium hypadenum

Outer nectaries located on the receptacle, in the sinus of the bracts; leaf-margins not undulate.

Involucres open at the angles, the bracts small, oval, narrowed at the base, not auricled; pedicels swollen at the base, often slender, attaining more than 3 times the length of the mature bolls; fruiting branches short, usually of 1 or 2 slender internodes

Gossypium patens

Involucres usually closed at the angles; bracts cordate, auricled or expanded at the base, below the point of attachment; pedicels stout and short, seldom exceeding the length of the boll.

Bolls flat-sided, square or pyramidal, with no oil-glands over the sutures; the locks held compactly in the open bolls by numerous fibers attached to the carpel walls

Gossypium contextum

Bolls rounded in section; oil-glands not interrupted over the sutures; the cotton not held in the open bolls by fibers attached to the carpel walls

Plants producing a vegetative and a fruiting branch from most of the nodes on the upper part of the stalk; these vegetative branches horizontal, bearing many short fruiting branches; flowers white with large red petal-spots; bolls smooth, oblong-elliptic with a short abrupt beak.....

Gossypium dicladum

Vegetative branches confined to lower nodes, large and ascending as secondary stalks; flowers white, with no petal-spots; bolls distinctly pitted, conic-ovoid, with a long acuminate point.....

Gossypium morrilli

Gossypium hypadenum, new species

Plants with strong, upright shoots attaining a height of about 10 feet in the first season. Very young stems and margins of the bracts slightly pilose, but all adult parts appearing entirely naked.

Leaves of rather thin papery texture, light green, glabrescent, deeply cordate and auricled, entire or with 3 to 5 broadly triangular lobes, with long acuminate points, side lobes usually very short, often represented only by a tooth; callus red, even on young leaves; petioles held in erect or strongly ascending positions and at smaller angles to the blade than in other cottons; upper side of petiole with a sharp median crest or angle, more distinct on the upper pulvinus, but running well down. Leaves of the upright shoots attaining large size, with the margins undulate, or ruffled, contrasting with the flat surface; length of blade on midrib 17 cm., on the auricles 22 cm., width 24 cm., petiole 24 cm.; auricles very large, often overlapping. Leaf nectaries usually 3, those on midveins much farther up, often twice as far as those on the veins of the forelobes; stipules large and persistent.

Involucral bracts large, flat, deeply cordate and auricled, with 7 to 9 large, gradually tapering teeth, longer than the body of the bract; auricles regularly united on the margins at base almost to their full width; color of bracts light fresh green, sometimes reddened on the exposed side; bractlets not found; outer nectaries, a long narrow groove, simulating leaf nectaries, and located far down on a ridge of the pedicel, rather than in a depression of the receptacle; inner nectaries broadly triangular; no distinct swelling of the receptacle around the end of the pedicel as in the usual cotton types, where the nectaries usually are placed, but a gradual tapering down from the bolls, more like *Gossypium davidsonii*; calyx with long slender teeth, tailed, often exceeding the bud.

Flowers pale yellow, with no petal spots; stamens relatively few, with rather long filaments, anthers brownish, pollen very pale; stigma only slightly exserted.

Bolls rather small, elliptical, acuminate, 3-locked, with a band free of oil-glands along each suture, most of the oil glands being close to the fissures.

Type in the U. S. National Herbarium, no. 1,209,604, collected at Los Mochis, Sinaloa, Dec. 16, 1925, by O. F. Cook and J. W. Hubbard.

Gossypium patens, new species

A large branching shrub or small tree about 12 feet high, with trunk 3 or 4 inches in diameter. Fruiting branches short, practically one-jointed, the other joints very slender and seldom producing bolls. Usually the second joints diverge very strongly from the direction of the first on account of the swollen base of the pedicel.

Leaf forms showing a wide range of diversity; the large leaves of rather heavy texture, several inches across, of broad Upland forms; small leaves having distinct, somewhat attenuate lobes, suggesting Durango or Acala; also many simple, entire, subcordate leaves much like those of *Gossypium davidsonii*; petioles relatively short on the large leaves; stipules of vegetative branches long, linear, those of fruiting branches much shorter and broader.

Involucres small and open, the bracts oval, distinctly narrowed at base, flared at the angles; teeth 5 to 7, well forward, often none below the middle; bractlets usually present, double involucres of frequent occurrence; outer nectaries distinct, but small and uncolored, forming deep, round or short elliptic depressions in the strongly inflated surface of the receptacle; inner nectaries transverse, located in very deep grooves; pedicels often very long, 3 or 4 times the length of the boll, and with the base swollen as in *Thurberia*; some of the short pedicels much thicker than the internodes of the fruiting branches; calyx lobes with long attenuate tips often exceeding the bud, all five lobes tailed or only 3, with the others sharply angled.

Flowers white, no petal spots; stigma well exerted.

Bolls small, subrotund, abruptly apiculate, 2, 3, and 4 locked, usually 3; fissure deeply marked below, even in green bolls, extending completely to the receptacle; ripe open boll 3.5 cm. across, with beak about 5 mm. long, very distinct in dried state; seeds 4 or 5 in each lock.

Seed small, black, naked, except a small tuft of brown fuzz at beak; lint sparse, fine, silky, more than 1 inch in length, commonly $\frac{1}{2}$.

Type in the U. S. National Herbarium, no. 1,209,601, collected at Guaymas, Sonora, Dec. 8, 1925, by O. F. Cook and J. W. Hubbard.

Gossypium contextum, new species

A robust, spreading, bushy plant, with rather strong short-jointed stalks, hirsute branches and dense foliage.

Leaves heavy, deep green, densely pilose, entire or 3 to 5 lobed, deeply cordate and auricled, sinus often closed; an occasional tooth on the midlobe, or on the basal curves; leaves of the upright shoots attaining large size with very large auricles, often overlapping widely; length of blade on the midrib 20 cm., on the auricle 25 cm., width 27 cm., petiole 24 cm.; nectaries usually 3, even on rather small leaves; stipules present, but not prominent.

Involucral bracts deeply cordate, with long teeth, auricles united at the base; bractlets of common occurrence, often 3 together, usually 3 or 4 to an involucre; calyx with long triangular lobes, sometimes with tails as long as the bud.

Bolls of medium size, short and flat sided, pyramidal or square, with a short abrupt tip; oil-glands not present on a broad light green band over the suture; 3 or 4 locks, with 5 to 7 seed per lock.

Seed dark brown, smooth, with yellowish brown fuzz at base; lint rather sparse, from three-fourths to seven-eighths inches long, easily pulled from the seed, but strongly held in the locks by numerous fibers attached to the carpel walls.

Type in the U. S. National Herbarium, no. 1,209,602, collected at Los Mochis, Sinaloa, December 16, 1925, by O. F. Cook and J. W. Hubbard.

On account of the numerous fibers attached to the walls of the carpels; the open bolls of this species have a distinctive appearance, with the locks not emerging from the carpels, but somewhat drawn down from the opening and remaining a compact mass. This is in striking contrast with the behavior of the cotton in the open bolls of other species. In some cottons the locks remain in place, on account of the rough elastic fibre which "fluffs" and holds together. In other species the locks fall out soon after the bolls open, or the seeds separate gradually.

Gossypium dicladum, new species

A large, upright, densely foliated plant, with woody stems and hirsute leaves and branches, producing small horizontal vegetative branches from most of the joints to near the top of the plants, from the same nodes with the normal fruiting branches, and of about the same size, bearing bolls on small secondary fruiting branches, usually of 1 or 2 joints.

Leaves of medium size, cordate, entire or 3 to 5 lobed, with large forelobes nearly equal to the midlobe; length of blade on midvein 12 cm., on auricle 15 cm., width 18 cm., petiole 13 cm., extra teeth occasional on basal lobes, none on midlobe; auricles ample, often overlapping; texture rather heavy, brittle; nectaries usually one, near the base; stipules prominent and persistent on the young shoots.

Involucral bracts large, cordate, with rather large teeth, the auricles regularly united on the margins below to almost their full width; nectaries usually present; receptacles prominent and distinct; calyx with short sharp pointed lobes, but not tailed.

Flowers large, white, opening widely, with very large dark red spots on the claws of the petals; stamens numerous; anthers pale; stigma barely protruding beyond the staminal column.

Bolls oblong-elliptic, apiculate, 3 and 4 locked; oil-glands large and scattering; no distinct sutural bands without oil-glands.

Seed large, black, naked, except a tuft of greenish fuzz at beak; lint sparse, three-fourths to seven-eighths inches in length.

Type in the U. S. National Herbarium, no. 1,209,605, collected at Los Mochis, Sinaloa, December 16, 1925, by O. F. Cook and J. W. Hubbard.

The double branching habit, with a vegetative branch and a fruiting branch produced together from the upper nodes of the stalks, is a consistent and characteristic feature not previously recognized in any of the "tree" cottons. The greater tendency to produce vegetative branches is apparent even where the branches are very small, with only two or three leaves, but commonly they have several joints and produce bolls on short secondary fruiting branches. The vegetative branch as a whole is about the same size as the primary fruiting branch of the same node. A similar tendency to

produce two branches from the same node of the stalk has been recognised in the Kehohi cotton of eastern Guatemala.*

***Gossypium morrilli*, new species**

Tall plants bearing numerous long, short-jointed, fruiting branches with 10 to 12 nodes, often maturing bolls at each node, and frequently two bolls from the same node. Some plants very hairy, others notably less, but all distinctly pilose on new growth.

Leaves large dark green, of thin texture, with very broad lobes, strongly up-folded at the sinus; auricles ample, often overlapping on the large leaves; teeth occasionally on midlobes, forelobes and base; length of blade of large leaf, on midrib 15 cm., on auricle 22 cm., width 21 cm., petiole 18 cm.; leaf nectaries 3, even on rather small leaves; stipules rather large.

Involucral bracts broad, distinctly cordate at base, with inner margins united; bractlets occasionally present; pedicels short, triangular in cross section, but not sharply angled; receptacle distinct, but not much swollen around nectaries; outer nectaries often quite large, usually longer than broad, sometimes narrowed to a short groove; calyx lobes sharp-pointed, often tailed.

Flowers white, of very delicate texture; petals with hyaline areas around the yellow oil glands; stamens with long filaments; stigma slightly exerted.

Bolls small, conic-ovoid, with a long acuminate point, mostly with 3 locks, but often with 4; oil glands large and scattering, not interrupted on sutural bands.

Seed very small, black, naked except a small tuft of greenish brown fuzz at base; lint sparse, about 8 inches in length.

This species was obtained by Dr. Morrill from sand-dunes near the coast of southern Sonora in the Yaqui-Valley district.

Type in the U. S. National Herbarium, no. 1,209,603, collected Dec. 16, 1925, from a plant grown at Los Mochis, Sinaloa, by O. F. Cook and J. W. Hubbard.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED
SOCIETIES

PHILOSOPHICAL SOCIETY

935TH MEETING

The 935th meeting was held at the Cosmos Club on Saturday evening, March 20th, 1926. The meeting was called to order by President BOWEN at 8:15 p.m. with 75 persons in attendance.

The program of the evening consisted of an address by Professor MAX BORN of the University at Gottingen, on *New methods in the quantum theory*.

The Bohr-Sommerfeld quantum mechanics, which since 1915 has been used successfully to find the energy and radiation of an atomic system with not more than one electron, is exposed to the objection that it operates with unobservable quantities such as size of the electron orbit, orbital frequency (which is not equal to the frequency of the emitted light), and

* See *Weevil-resisting Adaptations of the Cotton Plant*, Bur. Pl. Ind. Bull. 85: 20. 1906.

especially the coordinates p_k , q_k of the electron at a certain time t . A generalized quantum mechanics has been proposed by Heisenberg, attempting to give up this unsatisfactory union of classical mechanics, quantum conditions, and correspondence principle and to replace it by a unique quantum kinematics of discrete energy levels.

That the place of the coordinates p_k , q_k of the moving electrons is taken by matrices of Hermitian type was shown by the speaker in the following way: The Fourier series for the coordinates of the old theory

$$q_k = \sum_n A(n) e^{2\pi i n t}; \quad p_k = \sum_n B(n) e^{2\pi i n t}$$

are replaced by two-dimensional schemes:

$$q_k = \begin{pmatrix} A(11) & A(12)e^{2\pi i(12)t} & A(13)e^{2\pi i(13)t} & \dots \\ A(21)e^{2\pi i(21)t} & A(22) & A(23)e^{2\pi i(23)t} & \dots \\ A(31)e^{2\pi i(31)t} & A(32)e^{2\pi i(32)t} & A(33) & \dots \\ \cdot & \cdot & \cdot & \\ \cdot & \cdot & \cdot & \\ \cdot & \cdot & \cdot & \end{pmatrix}$$

or in condensed form:

$$q_k = (A(mn)e^{2\pi i \nu(mn)t}) \text{ and } p_k = (B(mn)e^{2\pi i \nu(mn)t})$$

The coefficients $A(mn)$ are the amplitudes of the wave emitted when the system is jumping from state m to state n , and $\nu(mn)$ is the frequency of this jump, which obeys Ritz's combination principles:

$$\nu(mn) = \nu(mk) + \nu(kn)$$

For the product of two of such schemes we find, since no new frequencies must appear in the exponent:

$$p \cdot q = (C(mn)e^{2\pi i \nu(mn)t})$$

where

$$C(mn) = \sum_k A(mk) B(kn)$$

This is the well-known law of matrix multiplication.

Hamilton's equations must now be written in matrix form:

$$\frac{dp_k}{dt} = - \frac{\partial H}{\partial q_k}; \quad \frac{dq_k}{dt} = + \frac{\partial H}{\partial p_k}$$

while Sommerfeld's quantum conditions

$$\int p_k dq_k = n_k h$$

have to be replaced by

$$p_k q_k - q_k p_k = \frac{h}{2\pi i} 1$$

$$p_k q_l - q_l p_k = 0; p_k p_l - p_l p_k = 0; q_k q_l - q_l q_k = 0,$$

1 being the unit matrix whose diagonal terms are equal to unity while all others are zero.

The general theory of perturbation based on this idea is free from any convergence difficulties, which previously made the application of classical theory of perturbation very ambiguous and questionable.

The speaker then discussed a possible extension of this theory, namely, to replace the matrix calculus by a still more general operator calculus. (*Abstract by O. Laporte.*) The address was discussed by Messrs. HAWKESWORTH, LAPORTE, HERZFELD, and BREIT, and at the close Professor BORN was tendered a rising vote of thanks.

936TH MEETING

The 936th meeting was held at the Cosmos Club on Saturday evening, April 3, 1926. The meeting was called to order by President BOWIE at 8:15, with 45 persons in attendance.

The program for the evening consisted of a paper on *Recent developments in the theory of periodic systems of the elements*, by Dr. OTTO LAPORTE, and was illustrated with lantern slides. The paper was discussed by Messrs. HAWKESWORTH and TUCKERMAN.

Bohr's and Stoner's assignment of total and azimuthal quantum numbers n and k respectively to the electrons of the atoms was discussed with the object of showing that various chemical, physical and spectroscopic evidences suggest subdivision of the ordinary period of eight elements (e.g. Li-Ne, Na-A) into two subgroups of two and six elements; that is, we assume a subshell to be closed with Be, Mg, Zn, etc. Spectroscopic facts show that the electrons belonging to this shell of two have $k = 1$ whereas from B to Ne or Al to A, etc., six electrons with $k = 2$ are bound until the shell is closed again in the rare gases. The apparent irregularity of the first period consisting of but two elements H and He now vanishes immediately, since in H and He two 1, electrons are bound, the first period should be compared with the other groups of two and in writing down the periodic chart He must be placed in the second column together with Be, Mg, Zn, Cd, Hg. The thus asserted similarity of the spectrum of He with those of the alkaline earths actually exists. This viewpoint furthermore asserts the inequality of the four valency bonds of the carbon atom, since two of its electrons are bound in $2s$, and two in $2p$ orbits. This fact, although spectroscopically verified in C and the homologous elements Ti, Ge, Sn, still waits for its proof in chemistry.

Of the 18 electrons of A, two are bound in $1s$, 2 in $2s$, 6 in $2p$, 2 in $3s$, and 6 in $3p$. The occurrence of the ten high melting point metals is thus accounted for by the completion of a shell of 10 electrons of $3p$ type and likewise the occurrence of the palladium and platinum metals by 10 electrons of $4s$ and $5s$ character respectively. Similarly the occurrence of 14 rare earths means the binding of fourteen $4f$ electrons. It was pointed out that it is unjustified to write the last three elements Th, Ux, U into the fourth, fifth and sixth columns. One should rather expect here the beginning of a second

rare earth group, characterized by the binding of 5_k electrons. Whether or not this viewpoint is justified must be decided by investigating their optical and x-ray spectra.

It was finally illustrated how the cabalistic regularity of the periodic system which is contained in the scheme

$$\begin{aligned} 2 &= 2 = 2.1^2 \\ 2+6 &= 8 = 2.2^2 \\ 2+6+10 &= 18 = 2.3^2 \\ 2+6+10+14 &= 32 = 2.4^2 \end{aligned}$$

is explained by means of Pauli's exclusion principle which states that if with one n_k electron the atom is capable of assuming N different orientations in a magnetic field, with two equivalent n_k electrons it can not assume N^2 but only $N(N-1)/2$ orientations, with three $N(N-1)(N-2)/1.2.3$, etc. It thus follows that a shell of n_k electrons just contains $2(2k-1)$ elements which furnishes the above given scheme. (*Author's abstract.*)

937TH MEETING

The 937th meeting was a special meeting held jointly with the WASHINGTON ACADEMY OF SCIENCES and the Biological Survey at the Cosmos Club on Thursday evening, April 15, 1926. The meeting was called to order by President BURGESS of the ACADEMY at 8:15, with about 100 persons in attendance.

On behalf of the American Geographical Society Major Gen. SALTZMAN presented the Charles P. Daly Medal to Brigadier General DAVID L. BRAINARD, and Captain CROSLLEY presented the Cullom Geographical Medal to Dr. HARVEY C. HAYES. Major General GREELEY was present and spoke in appreciation of the attainments of General BRAINARD. The recipients accepted the medals with appropriate words of thanks.

The address of the evening was given by Dr. PAUL R. HEYL, on *Visions and dreams of a scientific man.*

H. A. MARMER, *Recording Secretary.*

BIOLOGICAL SOCIETY

690TH MEETING

The 690th meeting was held in the new assembly hall of the Cosmos Club 13 March, 1926, at 8:00 p.m., with President OBERHOLSER in the chair and 68 persons present. New member elected: JOHN P. HOLMAN.

T. S. PALMER reported the death of the female Brazilian cardinal (*Paroaria cristata*) which has spent the winter in the vicinity of the Department of Agriculture and on the Smithsonian grounds. The bird first appeared in September and has been fed regularly through the winter by many people. It was found in a weakened condition and put in a cage, where it died on 24 February. An examination of the body showed filaria and staphylococcus. The only previous record of a bird living here for several months in the wild state is that reported several years by Dr. P. BARTSCH. A. WIRMOR spoke of his experience with the bird in Argentina. It ranges south to Buenos Aires, which is not as cold as Washington, although snow sometimes occurs. It is common in the Chaco, and highly esteemed as a cage bird. F. C. LINCOLN reported that one was captured last fall in a bird trap at Indianapolis by a bird bander, who thought it might be a cross between a cardinal and a rose-breasted grosbeak.

PAUL BARTSCH reported that the mockingbird that has appeared at his bird feeding-counter for several years has returned this winter and eats suet for the first time.

JOHN C. PHILLIPS: *Introducing foreign and American birds into new localities* (illustrated by specimens).—Birds introduced into new regions show several types of response to the new environment. (1) They may disappear at once (some game birds and European song birds); (2) they may nest the first season, then quickly or gradually die out without nesting again (Hungarian partridge in the eastern States); (3) they may have a long period of only local success (European goldfinch in Massachusetts and eastern New York, skylark on Long Island and Vancouver Island); (4) they may propagate rapidly and spread into new territory (California partridge in Australia), with increase in size of broods and apparent immunity from natural enemies, but usually ultimately disappear; (5) they may become thoroughly naturalized (English sparrow and starling).

The history of bird importation in this country is little known before the '50's. Cagebird fanciers, particularly near Cincinnati, New York, and Portland, Oregon, and sportsmen have been the two most important agencies in introduction.

Among introduced game birds, all the west American species introduced in the East have failed, as has the Egyptian quail, which bred for one season, and disappeared. Valley quail, plumed quail, and Hungarian partridge have succeeded in the northwestern United States and Canada. Black-cock and capercaillie have failed in the eastern States and Canada. Several tropical species have recently been introduced on Sapelo Island, Georgia. The chachalaca has flourished, but the ocellated turkey has not. Guinea-fowl, introduced in the West Indies 200 years ago, have run wild and become a good game bird. (*Author's abstract.*)

PAUL BARTSCH, National Museum: *Some experiences with the birds of the Dry Tortugas* (illustrated).—The Tortugas are 68 miles southwest of Key West. This group constitutes one of the National bird reservations and is particularly interesting because here we find the only colony of Sooty and Noddy Terns breeding on the American Coast. Bird Key, a small sandy island only a few feet above sea level, some 400 feet in length and 200 feet in width, harbors annually no less than 30,000 of the Sooty and Noddy Terns. These birds have been breeding here for a long time. They were visited in 1832 by Audubon, and have been the object of attention from naturalists ever since. The Sooty Tern probably breeds there today as it did when first discovered, but the Noddy has undergone a tremendous change in nesting habits in the last decade, owing to the fact that several recent hurricanes have denuded the island of its woody vegetation. When Dr. BARTSCH first visited the group 14 years ago, the Noddy Tern bred in the Bay Cedars which formed an abundant thicket on this Key, and since their destruction they have been forced to abandon this mode of nesting, being slowly forced to the ground by the dying and breaking off of the dead branches of these shrubs. The birds, which were at first tree nesters, now cling to anything that suggests wood, branches of the old stubs of the Bay Cedars or the little branches on the ground pulled together to form a nest. The old boards from a wrecked house, being wood, in part satisfy the craving for a woody nesting site, and where these elements are wanting the Noddy has at last come to use a mere hollow, just as does the Sooty.

It has been an interesting change, which, while gradual during the last 14 years, may, nevertheless, be considered a rather abrupt transition from a tree building type to a ground nester. With this change in nesting habit has come a decided diminution in the numbers of the Noddy, while the Sooty has maintained itself in the usual number.

It is interesting to note that in the single palm tree standing on the island today, the Noddies are breeding in numbers in the axils of the leaves high above the ground.

The Biological Survey has now planted several hundred coconut palms on the island. Most of them are doing well and will furnish, it is hoped, adequate nesting site, as well as shelter from the glaring rays of the sun, to the young birds of both species.

All these transition changes of nesting were illustrated with lantern slides, as well as the home life of both species, likewise of other visiting water birds, such as large numbers of Man-o'-war, and three species of Boobies. Dr. BARTSCH also showed pictures of the breeding colonies of Roseate Terns on Long Key, and of the Common Tern colony on Bush Key, and of some of the other visiting birds, such as waders and herons. He mentioned that so far he had recorded 136 birds from the group, most of which, of course, are spring and fall migrants. (*Author's abstract.*)

S. F. BLAKE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

DR. ARTHUR L. DAY is at present engaged in investigations in California as chairman of the Advisory Committee of the Carnegie Institution of Washington on seismology.

DR. W. S. ADAMS, Director of the Mount Wilson Solar Observatory, was in Washington during the early part of June, on his return from New York, where the degree of doctor of science had been conferred upon him by the Columbia University.

Mr. W. C. Parkinson of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington left New York June 10 for the Huancayo Magnetic Observatory in Peru, where he will act as consultant in the installation of earth-current recording devices.

A lecture on *World migration as illustrated by the distribution of the redwood tree*, was given by Ralph W. Chaney at the Carnegie Institution of Washington, on May 25, 1926.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 16

JULY 19, 1926

No. 13

GEOLOGY.—*Notes on the igneous rocks of the northeast West Indies and on the geology of the Island of Anguilla.*¹ THOMAS WAYLAND VAUGHAN, Scripps Institution of Oceanography, La Jolla, California.

The following paper consists of notes on a collection of igneous rocks I made in the West Indies in 1914, with determinations of the different rock specimens by the late Prof. J. P. Iddings, and of supplemental notes on the geology of the Island of Anguilla.

IGNEOUS ROCKS AND A FEW ASSOCIATED SEDIMENTS FROM THE LEEWARD
AND VIRGIN ISLANDS

Before Professor Iddings' lamented death he examined and identified for me all the samples of igneous rocks I collected in the West Indies in 1914. After his death that collection and other specimens were sent to Dr. E. O. Hovey, who was making a general study of the volcanic rocks of the eastern West Indies. Since Doctor Hovey died before completing his investigations, it appears desirable to publish an annotated list of the rocks with Professor Iddings' determinations.

The only explanatory remark needed seems to be regarding L. I. 56, 58, and 60, from St. Bartholomew. The contact of the rock represented by these samples with the St. Bartholomew limestone was not seen. The presence below the St. Bartholomew limestone of pebbles (L. I. 54) of rock similar to the rock referred to by the numbers just mentioned suggests an age greater than that of the limestone, but L. I. 64, 65, and 66 represent rock obviously intruded into the limestone.

The geologic ages of the formation mentioned in the column headed "Geologic Occurrence" are as follows: Antigua formation, upper and middle Oligocene; St. Bartholomew, upper Eocene; Anguilla formation, lower Miocene.

¹ Received June 15, 1926.

LIST OF ROCKS FROM THE NORTHEASTERN WEST INDIES. DETERMINATIONS
BY J. P. IDDINGS

LOCALITY (FIELD) NUMBER	STATION NUM- BER	NAME OF ROCK	LOCALITY	GEOLOGIC OCCURRENCE
L. I. 18		Altered dacite or rhyolite	Antigua, Rat Island, north side, alt. 30-40 ft	Bedded tuff, older than the Antigua formation
L. I. 19		Basalt	Antigua, N. 18°E. from Langford Mill on slope of first ridge to the north towards Crosby's Mill	Intrusive into the An- tigua formation
L. I. 32		Dacite tuff	Antigua, eastern slope of hill at Bethesda Church, head of Wil- loughby Bay	Bedded tuff, older than the Antigua formation
L. I. 38		Dacite tuff	Antigua, north of All Saints Bridge, 4½ miles from St John	Older than the Antigua formation
L. I. 30		Holocrystal- line andes- ite	Antigua, summit of Drew's Hill	Younger than the An- tigua formation
L. I. 40		Altered andes- ite, brecci- ated	Antigua, Drew's Hill 110 ft below the summit	Younger than the Anti- gua formation
L. I. 44		Possibly mi- crocrypto- crystalline silica	Antigua, top of Gray's Hill	Bedded rock occurring with the bedded tuff; older than the Antigua formation
L. I. 47		Altered an- desite	Antigua, northeast foot of Montero Hill	Not definitely ascer- tained, probably younger than the An- tigua formation
L. I. 50		Altered basalt	Antigua, between Orange Valley and Church Bay, behind first hill back from the shore	Not definitely ascer- tained, probably younger than the Anti- gua formation
L. I. 51		Altered dac- itic rock	Antigua, west side of Burnfoot Hill	Appears to be younger than the Antigua for- mation
L. I. 55	6882	Much altered andesitic tuff	Antigua, English Harbor Village, east side of Falmouth Harbor	Not definitely ascer- tained
L. I. 56b	6883	Andesitic tuff	Antigua, Falmouth Har- bor, slope of Monk's Hill, alt about 100 ft	Younger than the Anti- gua formation
L. I. 56c	6884	Altered an- desitic glass	Same locality as L. I. 56b, but on top of the hill	Overlies L. I. 56b, there- fore younger
L. I. 58¹	6885	Altered tuff	Antigua, west and south slope of Monk's Hill	Unconformably overlies water-bedded tuff

LOCALITY (FIELD) NUMBER	STATION NUM- BER	NAME OF ROCK	LOCALITY	GEOLOGIC OCCURRENCE
L. I. 59 ^u	6896	Altered andesitic glass	Antigua, Barnabas	Seems to belong to the tuffs older than the Antigua formation
L. I. 54 ^u	6895	Altered pyroxene andesite	St. Barts, spur s. e. side of Anse Écaille Bay; alt 120 ft	Pebbles from conglomerate interbedded with St Bartholomew limestone
L. I. 56 ^u	6896	Holocrystalline pyroxene andesite	St. Barts, northwest end of point on which Ft. Gustaf stands, alt about 20 ft	Not definitely ascertained, seems older than Eocene St. Bartholomew limestone
L. I. 58 ^u	6898	Altered pyroxene	St. Barts, above Ballast Bay, alt 430 ft	Probably the same as L. I. 58 ^u
L. I. 59 ^u	6899	Altered pyroxene andesite	St. Barts, slope of divide between Carasol and Flammand bays, Carasol Bay side, alt 210 ft	Apparently intruded into the St Bartholomew limestone
L. I. 60	6900	Holocrystalline pyroxene andesite	St Barts, between Carasol and Flammand bays, Carasol Bay side of divide, alt 100 ft.	Seems to be older than the St Bartholomew limestone
L. I. 61	6901	Altered andesite	St Barts, south slope of divide up from Carasol Bay, alt 130 ft	Apparently the same as L. I. 59 ^u
L. I. 65	6906	Micro-quartz diorite or holocrystalline quartz-pyroxene andesite	St Barts, northwest side of head of Galet Bay, alt 140 ft	Intruded into St Bartholomew limestone The same as intrusion L. I. 64
L. I. 67	6908	Altered pyroxene andesite	St Barts, head of Mari-got Bay, just above sea level	Not ascertained
L. I. 68	6909	Altered pyroxene andesite	St. Barts, east end of island, Tortue bearing N 15°E, Grand Fond Mountain bearing S. 55°W	Not ascertained
L. I. 69	6910	Altered pyroxene andesite	St Barts, Grand Fond Bay; alt 60 ft	Not ascertained
L. I. 70	6911	Altered aphanitic dacite?	St Barts, south slope of La Croix Mountain	Not ascertained
L. I. 71	6912	Altered aphanitic dacite? Similar to L. I. 70	St. Barts, Brim Mountain, north slope	Not ascertained

LOCALITY (FIELD) NUMBER	STATION NUM- BER	NAME OF ROCK	LOCALITY	GEOLOGIC OCCURRENCE
L. I. 72 ^a	6913	Altered an- desite or dacitic tuff	St Barts, L'Orient Point; the basal bed	Underlies L. I. 72b
L. I. 72 ^b	6914	Altered dacit- ic ? tuff	St Barts, L'Orient Point, bed next above L. I. 72a	Overlain by St. Bartho- lomew limestone
L. I. 73	6916	Altered an- desitic tuff	St. Barts, L'Orient Bay, base of point on west side	Underlies St. Bartholo- mew limestone
L. I. 74	6917	Altered an- desitic tuff	St Barts, L'Orient Bay, east half, south side of bay	Underlies St. Bartholo- mew limestone
L. I. 77	6920	Altered mica- bearing an- desite	St Barts, Gouverneur Bay, west cove	Intruded as dike into St. Bartholomew lime- stone
L. I. 79	6922	Dacite	St Barts, volcanic peak, east side of Gouverneur Bay	Younger than St. Bar- tholomew limestone Compare with L. I. 70 and L. I. 71
L. I. 84	6927	Altered py- roxene an- desite	St. Barts, Anse Lézard, boulder in volcanic agglomerate and con- glomerate	Appears to lie below the Bartholomew lime- stone
L. I. 80	6931	Altered py- roxene an- desite	St. Barts, south of south east corner of Bay Flammand, n e side of main divide of the island	Intruded into the St. Bartholomew lime- stone
L. I. 89	6932	Altered an- desite, pos- sibly dacite	St Barts, col between St Jean and Chau- vette bays	Probably younger than the St Bartholomew limestone Compare this with L. I. 70, L. I. 71, and L. I. 79. Seems to me (T W V.) the same as L. I. 71 and L. I. 79
L. I. 90	6955	Altered tuff	St Martin, south of Red Hill, near Simson Bay	Post-Miocene
L. I. 91	6956	Laminated sediment	St Martin, Petite Écaille Bay, west of North Point	Probably Cretaceous
L. I. 92	6957	Holocrystal- line dacite	St Martin, Grande Écaille Bay, south of North Point	Post-Cretaceous
L. I. 93	6959	Micro-quartz- dacite or holocrystal- line pyrox- ene andesite	St Martin, west side of head of Cul de Sac Bay, Well's lodge	Post-Cretaceous

LOCALITY (FIELD) NUMBER	STATION NUM- BER	NAME OF ROCK	LOCALITY	GEOLOGIC OCCURRENCE
L. I. 95	6961	Finer grained, like L. I. 93	St. Martin, head of Orient Bay, Orient Bay side of divide between it and Grand Case Bay; from a pit	Post-Cretaceous
L. I. 108	6945	Fine-grained granite or quartz mon- zonite	St. Martin, east side of Grand Bay, southwest foot of peak 634 ft. high	Post Cretaceous, in- truded into L. I. 109
L. I. 109	6946	Banded meta- morphosed sediment	Same locality as L. I. 108	Probably Cretaceous intruded by L. I. 108
L. I. 110	6947	Fine-grained quartz dior- ite	Same locality as L. I. 108	Intruded into sediment L. I. 109 specimen taken back from con- tact L. I. 108 the dike form of this rock
L. I. 111	6948	Altered an- desite	St. Martin, east side of Ft. Amsterdam Hill	Intruded into sediments probably of Cretaceous age
L. I. 113	6950		St. Martin, Philipsburg- Marigot road, neck of land at southeast cor- ner of Marigot Bay	
L. I. 114	6951	Altered an- desite	St. Martin, Philipsburg- Marigot road; out of well east of Simpson Lagoon	Not observed, probably post-Cretaceous
L. I. 99	6975	Altered an- desitic tuff	Anguilla, Crocus Bay, Pelican Point	Unconformably overlain by the Anguilla forma- tion
L. I. 102	6969	Altered basalt	Anguilla, Road Bay, north side, near west ern end of point of land on N side of bay	Unconformably overlain by the Anguilla forma- tion
L. I. 9		Pyroxene an- desite	St. Kitts, Brimstone Hill N side, alt. 360 and 460 ft.	Probably post-Pleisto- cene in age
L. I. 10		Pyroxene an- desite	St. Kitts, 2½ mi from Basseterre on road to Old Road	Broken from a large boulder, geologic rela- tions not observed
L. I. 5		Altered an- desitic tuff	St. Croix, Frederiksted, Fort Catharina Hill	Apparently overlain by hard limestone.*
L. I. 1		Altered an- desite	St. Thomas, ½ mi. S E of Frederiksberg, half way between Fredericks- berg and Flag Hill	Not observed. This rock is mapped as "bluebeach" by Cleve

* In this limestone are included pieces resembling L. I. 5. The limestone seems to be of Middle Oligocene age.

A considerable volume of literature is now available on the igneous rocks of the West Indies. Papers by Högbom,³ Calkins,⁴ Earle,⁵ Fittke,⁶ and Burbank,⁷ are listed below, but these references do not exhaust the literature. I made in the Virgin Islands of the United States a considerable collection of igneous rocks which were examined by Mr. Clyde P. Ross of the U. S. Geological Survey but no report was finished for publication. I have published a few notes on these rocks in the papers cited below.⁷ I collected all the kinds of rocks mentioned by Mr. Earle in his paper on the Virgin Islands except pegmatite.

No review of present knowledge West Indian igneous rocks can be attempted in this article, but a few general remarks may be made. One of the striking features of the West Indian rocks is the persistence of rocks of the diorite-andesite group, with or without free quartz, virtually throughout all the known geologic ages. They extend from the probably Paleozoic Daguilla diorite schist of the Isle of Pines⁸ to the modern andesitic lavas of St. Kitts. A striking feature of the rocks is the almost complete absence of potash feldspars. This is only corroboration of what Högbom has so well expressed in his paper. The only rocks among those I collected and listed above which contains potash in a notable amount is my L. I. 109, on the east side of Grande Bay, St. Martin.

More basic rocks are also well developed in the West Indies; peri-

³ HÖGBOM, A. G., *Zur Petrographie der kleinen Antillen*. Geol. Inst. Upsala Bull., 6: (pt 2), 214-232, pls 9, 10, 1905

⁴ CALKINS, F. C., *Metamorphic and igneous rocks*, in Geol. Recon. Dominican Repub., by T. W. Vaughan and others, Geol. Surv. Dominican Repub., Mem., 1: 83-88, 1921. Also in Spanish edition.

⁵ EARLE, K. W., *Report on the geology of Antigua*, Govt. Printing Office, Leeward Is., 1923 28 pp

—, *The geology of the British Virgin Islands*, Geol. Mag., 61: 339-351, 1924

—, *Reports on the geology of St. Kitts-Nevis, B. W. I., and the geology of Anguilla, N. W. I.*, Published by the Crown Agents for the Colonies, London. Pp. 50.

⁶ FITTKE, C. R., *The geology of the Humacao District, Porto Rico*, N. Y. Acad. Sci. Scientific Survey of Porto Rico and the Virgin Is., 2: (pt. 2) 117-197, text-figs., and map, 1924. (Much other information has been published by the N. Y. Acad. Sci., see bibliography of this paper.)

⁷ BURBANK, W. S., *Igneous rocks, Geology of the Republic of Haiti*, by W. P. Woodring and others, pp 280-330, 1924. Repub. Haiti, Dept. Public Works. Also in French edition.

⁸ VAUGHAN, T. W., *Stratigraphy of the Virgin Islands of the United States, etc*, THIS JOURNAL 13: 303-317, 1923. (In the bibliography at the end of this paper I failed to list the very important paper by Professor Högbom, for which see foot-note 2 of this paper) *A sketch of the history of igneous activity in the northern and north-eastern West Indies*, Third Pan-Pacific Science Congress, Australia, 1923, Proc., 1: 851-55, 1925

⁹ HAYES, C. W., *Report on a geological reconnaissance of Cuba*, Rept. of the Military Governor for 1901, p. 115, 1902.

dotites, usually metamorphosed into serpentinite, gabbro, and several kinds of basalts are known.

Regarding the igneous rocks of Anguilla, Mr. Earle says:

The igneous rocks forming the basement beds of Anguilla and Dog Island do not differ essentially from those forming the foundations of St. Kitts and Antigua to the south and are all parts of the Antillean "province" as distinct from the very different suite of igneous rocks forming the Virgin Island "province."

As regards the similarity of the mode of occurrence of the igneous rocks in Anguilla to those in Antigua Mr. Earle is right, but there are andesites and dacites of probably Triassic or Jurassic age in Haiti; andesites and andesitic tuffs of Cretaceous age occur in St. Thomas and probably in St. Croix; and andesitic tuffs are interbedded with Eocene sediments in St. Bartholomew. In Cuba, in the Province of Santa Clara, quartz diorite underlies Upper Cretaceous sediments; dioritic rocks are intruded into Cretaceous sediment in St. Thomas, Culebra, Vieques, and elsewhere; in St. Bartholomew holocrystalline andesite is both older and younger than the Eocene sediments; in Haiti quartz diorite is intruded into Eocene sediments. Igneous rocks of the chemical composition indicated extend in age from pre-Cretaceous to present time in the West Indies. Gabbro and basalt have about the same geologic range but do not occupy so large areas. Peridotite and serpentinite are extensively present in Cuba, the Dominican Republic, and Porto Rico, and are present in the republic of Haiti. They are mostly of Mesozoic age.

NOTES ON THE GEOLOGY OF ANGUILLA

Some months ago I received a copy of Mr. Kenneth W. Earle's paper entitled "The Geology of Anguilla, B. W. I.,"⁹ in which he says that he does not understand a generalized, composite section I published¹⁰ of the exposures adjacent to Crocus Bay and he disagrees with my statement that the Anguilla formation rests on igneous rock at Crocus Bay.

My original characterization of the Anguilla formation is as follows:¹¹

Anguilla formation. This formation is uppermost Oligocene, if the Aquitanian of Europe is correctly referred to the Oligocene. In the opinion of some paleontologists it would be classified as earliest Miocene. It is paleontologically characterized by certain Foraminifera, described by J. A.

⁹ Published by the Crown Agents for the Colonies, 4, Millbank, London, S. W. 1, without date.

¹⁰ U. S. Nat. Mus. Bull., 103: 262, 1919.

¹¹ THIS JOURNAL, 8: 271, 1918.

Cushman in a report not yet published; by numerous species of corals, among which are the genera *Stylophora*, *Stylocoenia*, *Antillia*, *Orbicella*, *Siderastrea*, and *Goniopora*; by echinoids described by Guppy or by Cotteau, among which are *Echinolampas semiorbis* Guppy, *E. lycopersicus* Cotteau, and *Agassizia clevei* Cotteau; and by a number of species of Mollusca, described in manuscript by C. W. Cooke. The Mollusca include *Amusium lyonii* Gabb and *Orthaulax pugnax* (Heilprin). I obtained no specimens of *Lepidocyclus* in Anguilla. The type exposure is along the southeast and south shore of Crocus Bay. The material consists of calcareous clay, argillaceous limestone, and more or less pure limestone. The formation unconformably overlies basic igneous rock.

Mrs. Burdon reprinted the paragraph quoted above, accompanied by a few notes I gave her on Anguilla, in her useful little volume entitled "A Handbook of St. Kitts-Nevis, a Presidency of the Leeward Islands Colony, containing information for residents and visitors concerning the Islands of St. Christopher or St. Kitts, Nevis and Anguilla."¹²

The description of the generalized section mentioned above which I published reads as follows:

GEOLOGIC SECTION AT CROCUS BAY, ANGUILLA

- | | |
|--|----------|
| 3. Hard cavernous limestone, with few or no corals | 60 feet |
| 2. More or less argillaceous limestone with some beds of harder, purer limestone, contains fossil corals from bottom to top, some coral heads as much as 2 feet in diameter; this member subdivisible into subordinate beds, about | 200 feet |
| 1. Yellow and brownish clay underlain by dark blue-black clay, or by sandstone and conglomerate of igneous material, overlying basic igneous rock (exposed at Pelican Point) | 5 feet |

I have discussed some of the geological features of Anguilla in other papers listed below.¹³

¹² Published by authority of the Government of St. Kitts-Nevis by the Crown Agents for the Colonies London, The West India Committee, 1920, see pp. 232, 233

¹³ *The platforms of barrier coral reefs*, Amer. Geogr. Soc. Bull., 48: 427-428, 1914.

Studies of the stratigraphic geology, etc., of several of the smaller West Indian Islands, Carnegie Inst. of Washington, Yearbook for 1914, pp. 13, 14, 1915.

Some littoral and sublittoral physiographic features of the Virgin and northern Leeward Islands and their bearing on the coral reef problem, THIS JOURNAL, 6: 61, 62, 1916. Abstract in Geol. Soc. Amer. Bull., 27: 44, 1916.

Fossil corals from Central America, Cuba, and Porto Rico, etc., U. S. Nat. Mus. Bull., 103: 209, 262, 276, 277, 1919; *The biologic character and geologic correlation of the sedimentary formations of Panama*, Ibid., p. 585.

Correlation of the Tertiary formations of Central America and the West Indies, First Pan-Pacific Sci. Congress Proc., Bishop Mus. Special Pub., pp. 832, 833, 1921.

Stratigraphic significance of the West Indian species of fossil Echini, Carnegie Inst. Washington, Pub., 306: 113, 114, 1922.

Criteria and status of correlation and classification of Tertiary deposits, Geol. Soc. Amer. Bull., 35: 733, 1924; *American and European Tertiary larger foraminifera*, Ibid., 803.

During 1914 I spent nearly two months in geological field work in the northeastern West Indies and I was in Anguilla from February 28 until March 8. While on the island I made careful studies of the exposures along and near the shores of Crocus Bay and less detailed studies of very nearly the entire island, but I did not visit the outlying islands. Some of these were viewed through field glasses and Mr. Carter Rey gave me a number of notes on them. Since the exposures in Anguilla, especially those in the vicinity of Crocus and Road Bays, are of much importance in the study of the West Indian Tertiary formations, it seems desirable to present more detail than has hitherto been published.

No general description of the physical features of the Island will be given here, since such descriptions are available in several papers, the earliest with which I am acquainted being "Reports on the Geology of Jamaica" by Sawkins and others, 1869. The description in the British Admiralty's "West India Pilot," vol. 2, pp. 289-296 is good. The general map of Anguilla I have used is chart no. 1834 of the Hydrographic Office, U. S. Navy, which is based on a British Survey made in 1847 and subsequent small corrections. A detailed chart of Crocus Bay is published as one of several harbor charts on chart no. 371a of the Hydrographic Office, U. S. Navy. This chart is based on British surveys made in 1846, corrected to 1883.

Crocus Bay lies on the northwest side of Anguilla between two points of land of which the more southern projects farther west than the one at the north. The extreme distance across the harbor opening is about 1.9 sea miles. The maximum distance from a line between the seaward ends of the bounding points to the bay shore is about 0.8 sea mile. The bay is open toward the west. The end of the northern point is known as Flat Cap. The sea between slopes gradually from a depth of 9 fathoms in the outer part of the bay to the shore.

The highest land adjacent to Crocus Bay is at the Customhouse, whose altitude is 218 feet above sea level. From Valley Postoffice, where the bay extends farthest into the land, there is a gradual slope to sea level from an altitude of about 140 feet. Most of the slopes around the bay are steep, even precipitous. The Customhouse stands only about 800 feet back from the water's edge according to the chart, the slope there being almost 1 foot in 4 feet.

The following description of the section exposed between the Customhouse and the water's edge at Crocus Bay is a composite,

since all of the section could not be seen in one continuous bluff face or slope. The lower 6 beds were examined along the foot of the bluff and in its northeastern part on the south side of the slope from Valley Postoffice to the shore of the bay. At a height of about 90 feet above sea level the line of the section was shifted southward to a steep-faced bluff which rises to a height of about 185 feet above sea level. Several aneroid barometer readings gave the height of the top of the bluff above sea level as between 175 and 200 feet, which is too low, the actual height by the chart being 218 feet. A correction has, therefore, been applied to the aneroid readings in order to make the thickness of the beds equal the height of the bluff. The measurements are only approximate. The exposures along the southeast shore of the Bay are nearly along the strike of the beds, which is southwestward; the dip is southeastward, at an angle of perhaps 10° —precise measurement is not practicable.

DESCRIPTION OF SECTION ON THE SOUTHEAST SHORE OF CROCUS BAY, NEAR VALLEY POSTOFFICE (THICKNESSES ONLY APPROXIMATE)

	Thickness in feet
8. Limestone, massive, hard, exposed at the Customhouse, 218 feet above sea level, overlies the coralliferous limestone and marls exposed below.	
7. Limestone, yellowish, argillaceous, with interbedded harder limestone which forms discontinuous beds or bands. A large number of corals and some echinoids were collected from exposures equivalent in stratigraphic position to the upper half of this part of the section, field no. L. I. 96 (1914). About 40 ft above the base of this division corals, three species of echinoids, <i>Amusium</i> , <i>Spondylus</i> , etc., were collected field no. L. I. 100c (1914).	130
6. Limestone, harder, but with considerable clay, colored yellowish to red with oxides of iron	12
5. Limestone, more argillaceous, zones of nodular limestone in clay; many corals, some excellently preserved, part of collection field no. L. I. 100b (1914)	30
4. Limestone, harder, base of the <i>Echinolampas semiorbis</i> bed, corals abundant, part of collection field no. L. I. 100b (1914)	12
3. Yellowish calcareous clay and yellowish argillaceous limestone. Much of the more calcareous parts form more or less nodular bands embedded in more argillaceous matrix. Fossils are abundant in this part of the section: " <i>Orbitolites</i> ," <i>Miogyopsis antillea</i> , <i>Stylophora</i> , <i>Orbicella</i> (heads 2 ft in diameter), <i>Goniopora</i> (heads 2 ft in diameter), <i>Porites</i> , some echinoids, <i>Ostrea</i> , <i>Pecten</i> , <i>Spondylus</i> , <i>Turritella</i> , etc. In some places <i>Miogyopsis antillea</i> makes up most of the rock. Collection field no. L. I. 100 (1914) mostly from the lower part; field no. L. I. 100a (1914) solely from lower 10 ft of this division	30
2. Yellowish, brownish, and chocolate-covered clay	3
1. Base of bluff. Blue-black clay in which lignite and amber have been found. This corresponds to the bed immediately overlying the volcanic sandstone and conglomerate and andesitic tuff on the north side of the bay	2
Total thickness, approximately	219

On the north shore of Little Harbor, northern part of Crocus Bay, near Flat Cap Point, there is the following exposure:

SECTION, LITTLE HARBOR, CROCUS BAY

	Thickness in feet
3. Hard, massive, cavernous limestone, many caves, some 50 ft. in depth pit in one of them Mr. Carter Key collected specimens of <i>Amblyrhiza</i>	From a 60
2. Laminated calcareous sandstone	15
1. Argillaceous yellow limestone with many fossil corals, especially branching poritids	20

There has been much faulting between Flat Cap and Pelican Point, as noted by Mr. Earle, and the dips are greatly disturbed. I made no attempt to unravel the details of the faulting, although several records of the strike of the fault lines and the direction of the downthrow were made.

I interpret the hard cavernous limestone in the bluff on the north side of Little Harbor as representing the same horizon as that at the Customhouse. This limestone is no. 3 of my section quoted on page 352 of this article and its thickness is set down as 60 feet. The "60" should be followed by a plus sign. At Sandy Hill, east of Forrest, similar hard limestone overlies argillaceous coralliferous limestone. No. 2 of the section quoted includes beds nos. 3 to 7 of the more detailed section of the bluff below the Customhouse; and no. 1 of the quoted section includes nos. 1 and 2 of the section here given. I made extensive collections from member no. 3 of the generalized section, and the different collections were labeled and given field numbers, the height above sea level of the different lots being indicated on the labels. All of the material I obtained has been described and the descriptions published except for some of the corals. I described a part of the corals and discussed the ensemble of the coral fauna in U. S. Nat. Mus. Bull. 103. The beds between the underlying volcanic sandstone and andestic tuff and the base of the overlying hard cavernous limestone, no. 3 of the generalized section, belong to the Anguilla formation. I am not certain of the classification of the uppermost limestone but incline toward including it in the same formation.

Regarding the kind of rock on which the Anguilla formation rests at Pelican Point a note in my notebook reads as follows:

Pelican Pt. bedded agglomeratic sandstone and conglomerate. Material averages coarser toward the base and finer toward the top, but beds of finer and coarser material alternate; grades into clayey material at the top; underlies the limestone. Strike north and south; dip eastward, 35°. Field no. L. I. 99 (1914). This material is similar to that which underlies the limestones in both St. Barts and St. Martin.

The beds here are disturbed, as pointed out by Mr. Earle. The material I collected at Pelican Point was submitted to the late Prof. J. P. Iddings for determination and he pronounced it "altered andesitic tuff." If in my papers I had said that the clays forming the basal part of the Anguilla formation rested on the eroded surface of an altered andesitic tuff instead of "basic igneous rock" my statement would have been precisely instead of approximately correct. Professor Iddings determined my specimens (field no. L. I. 102, 1914) of igneous rock from Road Bay as "altered basalt."

I shall not discuss the propriety of calling an andesitic tuff an igneous rock, but I shall say that tuffs interbedded with sedimentary rocks are common in the West Indies and in many instances it is not easy to decide whether the rocks should be classified as sedimentary or volcanic rocks. Since Mr. Earle says "These lowest beds contain abundant angular fragments of volcanic rock of andesitic type and evidently represent the first epoch of submergence of the igneous rocks below the sea prior to the deposition of the limestone" his opinion does not differ substantially from what I had already published.

The general section at Road Bay is so similar to that exposed at Crocus Bay that a detailed description of it is unnecessary.

I now think that the Anguilla formation may be of Langhian (Burdigalian) instead of Aquitanian age. (See my 1924 papers.) Besides their bearing on problems of stratigraphic geology, the Anguilla formation and its geological relations are of interest because of the evidence they supply on the conditions under which coral-reef limestones form. I think J. W. Spencer correct in regarding the formation as "a part of the coastal plain extending from the mountains of St. Martin."¹⁴ The deposit in Anguilla was laid down some distance offshore, it rests unconformably on a basement of volcanic rock, and the amount of submergence indicated by the thickness of the formation exceeds the depth at which the kinds of corals found in it thrive. The reef corals grew up on a basement which subsided to a depth greater than that at which reef corals live but without interrupting the continuity of reef formation. The reef was probably of the barrier type, although the lagoon may later have been filled and limestone with few or no corals laid down over the reef.

J. W. Spencer postulates the presence of a limestone of late Pliocene age over the Anguilla formation, from which it is separated by an unconformity, but I doubt the correctness of this interpretation, since

¹⁴ Geol. Soc. London Quart. Journ., 57: 520-533, 1901.

the dip of the lower beds as given by SPENCER, 40° northeastward, is a disturbed dip and the higher more nearly horizontal limestone probably does not rest directly on beds with such discordance in dip. Mr. Earle says:

At some points on the east side of Crocus Bay and eastwards along the coast from Flat Cap there is very fine-grained coral limestone unconformably overlying the Oligocene beds and dipping steeply (as much as 30°) west, i.e., towards the sea. This is a very soft, fine-grained material without megascopic fossils, consisting essentially of very finely comminuted fragments of coral rock. Its very marked flaggy bedding is more apparent than real, for the rock will not split along the bedding planes, breaking only with an irregular fracture. A very fine exposure of this rock is seen two miles northeast of Island Harbour, and is evidence of the very important uplifts that have affected the island in (geologically) recent times.

Although I should not be justified in denying the presence of a very young limestone unconformably overlying the Miocene deposits, I doubt the correctness of the interpretation of both Spencer and Earle. I examined on the northeast side of Pointe Blanche, St. Martin, an exposure of flaggy calcareous sandstone which overlies the older, probably Cretaceous, flaggy sandstones and shales, and appears to be a Pleistocene or younger deposit that has been uplifted about 20 feet. I saw no deposit of this kind in Anguilla.

Evidence of geologically recent subsidence in Anguilla has been presented in several of my papers. I have published descriptions and profiles of the submarine terraces, descriptions of the bays and the bay bars, and descriptions with an illustration of the enclosed ponds, the bottom of several of which are reported to communicate with the sea.¹⁴ Mr. Earle mentions "the underground communication between enclosed basins in the limestone and the sea."¹⁵ He attributes the "beaches across the mouths of the coastal inlets" to elevation. The formation of the bay bars is due primarily to submergence, which produced a bay, across the mouth of which a bay bar later formed. I am not sure whether or no there has been a minor emergence in the West Indies similar to that described for Samoa by Daly and for the Hawaiian Islands by Wentworth and Palmer. It appeared to me that there probably had been such an emergence in Antigua and perhaps in St. Bartholomew, but the evidence was not entirely conclusive. A more detailed study was needed than I was able to make

¹⁴ U. S. Nat. Mus. Bull., 103: 276, 277, pl. 69, fig. C, 1019. (The figure illustrates Call's Pond.)

¹⁵ EARLE, K. W., *Report on the Geology of Antigua*. Govt. Printing Office, Leeward Is., 1923, p. 41.

during my visit to the islands. I did not notice any definite elevated terraces in Anguilla such as are common in the Dominican Republic, Haiti, and Cuba. Since I was particularly looking for them, I think if they were there I should have seen them.

Note: Since this manuscript was written I have received a copy of Prof. W. M. Davis's volume "The Lesser Antilles," published by the American Geographical Society, a valuable contribution to the literature on the West Indies, but I do not agree with his opinion that there was a great development of Tertiary atolls in the West Indies.

GEOLOGY.—*The geological age of Tuolumne Table Mountain, California.*¹ OLIVER P. HAY, Washington, D. C.

The writer has had occasion to study the geology and vertebrate paleontology of the Gold Belt of California. In this study he has made use of the works of Whitney, Lesquereux, Diller, Leidy, Knowlton, Holmes, Ransome, Turner, Lindgren, and Sinclair. Lindgren's paper, "The Tertiary Gravels of the Sierra Nevada,"² sums up the situation and has been a prime source of information.

Whitney made the brilliant observation that the western slope of the Sierra Nevada had been traversed in the Tertiary by great river valleys which afterward became choked up by flows of volcanic materials. The streams, being thus displaced, were compelled to cut for themselves new courses, the present canyons of that slope. Relying especially on the fossil plants Whitney concluded that the ancient valleys had been filled and obliterated, at the latest, during the Pliocene, and this view was accepted by most persons interested in the subject. The later geologists came to recognize effaced valleys of different ages, some whose beginning extended back into the Eocene or even the late Cretaceous. In fossils coming from some of these volcanic deposits Leidy recognized certain animals which belonged in the Oligocene. Other valleys were seen to have had a later and shorter history.

From the point of view of the vertebrate paleontologist, also perhaps of the anthropologist, Tuolumne Table Mountain is of special interest, for to it and to near-by localities were credited many extinct mammals and many relics of man.

When Whitney sent to Joseph Leidy remains of a wolf from some

¹ Received May 24, 1926.

² LINDGREN, Profess. Pap. U. S. Geol. Surv., No. 73, 1911.

of the auriferous gravels Leidy warned him that the animal and the deposits belonged to the Quaternary, but Whitney replied² that there were abundant reasons for classing them as Pliocene. In 1899³ Prof. W. H. Holmes investigated the region about Table Mountain and sought to show that the reports regarding the discovery of relics of early man were untrustworthy; and that if true they would tend to prove the former existence of a Middle Tertiary people. Dr. W. J. Sinclair, writing in 1908,⁴ concluded that, if the implements were found as claimed, it would mean that a high type of man was contemporary with the three-toed horse. However, those who consult Lindgren's paper cited above will learn that Table Mountain is a relatively young formation. And here it may be noted that the later geologists have taken arbitrarily as the moment of transition from Pliocene to Pleistocene the end of the eruptive period; admitting, however, that this limit may not coincide with that of the rest of the world.

On his page 215 Lindgren informs us that the river valley in which were planted the roots of Table Mountain had its beginning late in the period of eruptions. The old valleys which had persisted up to this time had already become filled quite to their brims, and a new outlet for the drainage was required. This new watercourse, now called Cataract Channel, eroded rapidly, cutting through the old lava flows and down some hundreds of feet in the bed-rock. Later, new eruptions in the high Sierra occurred which in time clogged the new valley with volcanic mud and finally put a cap of basalt on top of all. This in its turn led to the excavation of the present canyon of Stanislaus River and the conversion of Cataract Channel and its contents into Table Mountain.

A basin of limited area near the village of Columbia was crossed by Cataract Channel.⁵ In the deposits of this basin, mostly of volcanic tuffs, the miners found many fossil animals, especially mastodons and elephants, but also horses, a bison, a tapir, and a camel. These are all Pleistocene animals. Some of the horses were identified as *Equus occidentalis*, a species found in the tar pits of La Brea, near Los Angeles. A few miles away, in other auriferous gravels, remains of *Equus pacificus* were discovered, a species known from near San Francisco and from Fossil Lake, Oregon.

² Aurif. Gravels, p. 246

³ Ann. Rep. Smithsonian Inst'n. for 1899, published 1900, pp. 419-472.

⁴ Univ. Calif. Publ. Amer. Arch. Ethn., 7: 129-130.

⁵ LINDGREN, op. cit., p. 216.

On his page 266 Whitney published the affidavit of a man who testified that he had taken a mastodon tooth out of a car-load of auriferous gravels coming out of a tunnel from under the basalt of Table Mountain, 200 feet in and at a depth of 125 feet. In 1871¹ Leidy reported having received a fragment of a mastodon tooth which Whitney informed him had been obtained from a depth of 80 feet beneath the basaltic lava. In 1868² Prof. B. Silliman became sponsor for the occurrence of a considerable part of a mastodon skeleton beneath the basalt of Table Mountain, 1,600 feet from the mouth of the tunnel. The description of the tusk and teeth indicates that the species was *Mammot americanum*. The tusk was slightly curved, 6 inches in diameter, and 7 feet long. Originally it may have been 10 feet long. Two hindmost molars were each 6 inches long and 3.5 inches wide. The worn penultimate molars were each 4.5 inches long and 2.75 inches wide. Besides this description, sketches of the teeth were sent to Silliman, who wrote that there was no room for doubt that these remains were those of the mastodon. Professor Silliman also secured for Yale College a point of a tusk and an ilium of a mastodon which had been discovered in another tunnel at a distance of 1500 feet from the mouth. He "obtained the plainest possible testimony of eye witnesses to the fact that these bones had been taken from beneath the basalt." As to the species of this specimen we have not the same assurance.

One can hardly doubt that the mastodons found under the basalt were of the same geologic age as fossils found in and around Columbia. These, embracing the two extinct species of horses and a camel, are, in the writer's opinion, of first interglacial age. The mastodons beneath the lava could hardly have existed on the summit of the Sierra range during the cold climate which characterized the close of the Pliocene and the first glacial stage. They cannot be referred to any stage later than the first interglacial, for that would make the basalt too young. Taking into account, then, what Lindgren says about the age of the valley and its volcanic contents, and the nature of the fossils found all around Table Mountain and those buried beneath it, the writer concludes that Table Mountain is a product of the first interglacial stage. It appears probable that the valley had its beginning with the Pleistocene. During the first stage of this epoch, the earliest glacial, the cutting was accomplished. Then eruptions began anew,

¹ Proc. Phila. Acad. Nat. Sci., 23: 50.

² Amer. Journ. Sci., ser 2, 46: 378.

the valley was refilled, and the mastodons and the other animals were buried in the debris. Probably at a late time in the first interglacial stage the basalt was belched out and this material crowned the mountain. That this basaltic flow occurred at a somewhat advanced time in the Pleistocene is shown by the presence of remnants of basalt in Stanislaus canyon, 1,500 feet above the river.⁹

In regard to the reputed discovery of human relics in the auriferous gravels the writer believes that Professor Holmes did good service when he pointed out the inadequacy of the evidence furnished. Nevertheless, some of those asserted discoveries of human bones and artifacts in previously undisturbed auriferous gravels may have been real. If so, such remains of man's framework and of his handiwork would prove, not the existence of Tertiary man, but of man of the second stage of the Pleistocene. The case becomes then one of perhaps fifty in our country in which relics of man are so closely associated with early Pleistocene vertebrates that the efforts of some of the ablest geologists have been taxed to cast doubt on the meaning of the association.

BOTANY.—*Notes on Disterigma*.¹ S. F. BLAKE, Bureau of Plant Industry.

The subgenus or section *Disterigma* of *Vaccinium*, proposed by Klotzsch² in 1851 for eight South American species, was raised to generic rank almost simultaneously in Niedenzu³ and Drude⁴ in 1889. Drude placed the genus in the tribe *Vaccinieae*, while Niedenzu, on the strength of the leaf anatomy, referred it to the *Thibaudieae*. Horold, in his treatment⁵ of the American *Thibaudieae*, placed *Disterigma* next to *Oreanthes* Benth. and listed 13 species (two of doubtful position), divided into two groups according to the entire or serrate leaf margin, a somewhat variable and unsatisfactory basis for separation. The 22 species now known form a compact group, probably generically distinct from *Vaccinium*, but perhaps later to be united with some one of the related South American genera when the whole tribe is studied monographically. For the present, however, it seems best to retain *Disterigma* as a genus, characterized chiefly by its usually

⁹ LINDGREN, op. cit., p. 215.

¹ Received May 29, 1926.

² *Linnaea* 24: 57. 1851.

³ Bot. Jahrb. Engler 11: 160. 18 June 1889. See also pp. 209-210, 247.

⁴ In Engl. & Prantl. Nat. Pflanzenfam. 4: 52. Aug. 1889.

⁵ Bot. Jahrb. Engler 43: 251-334. 1909.

solitary and subsessile generally tetramerous flowers with the ovary embraced by two comparatively large bracts. Of the known species, two occur in Costa Rica and Panama, the others in the Andes from Venezuela and Colombia to Bolivia and Peru.

The genus *Vacciniopsis* Rusby, described in 1893 and compared with *Vaccinium* but not with *Disterigma*, can not be separated from the latter. The original species, *V. ovata*, is distinct from any described *Disterigma*, while the second, *V. tetramera*, described by Rusby in 1920, is apparently identical with *D. dendrophilum* (Benth.) Niedenzu.

The following notes are based on material of *Disterigma* in the National Herbarium, supplemented by a number of specimens lent for study from the Gray Herbarium and the New York Botanical Garden, through the kindness of Dr. B. L. Robinson and Dr. N. L. Britton.

Disterigma elassanthum Blake, sp. nov.

Shrub, with long leafy branches and fastigate branchlets, these densely rusty-pilose with loosely spreading to ascending hairs; leaves ovate, small, sharply acuminate, entire; flowers axillary, solitary, subsessile, bracts orbicular, at first equaling the ovary; corolla subglobose, about 3.5 mm. long; filaments glabrous, 0.6 mm. long, the anthers 1.6 mm. long, the tubules twice as long as the sacs.

"Shrubby vine," 70 cm. high and more; branches mostly denudate of leaves, with gray fissured bark, grayish-pilose or glabrescent; petioles 0.5-1 mm. long; leaf blades 6-9 mm. long, 2.5-4 mm. wide, rounded or subcordate at base, coriaceous, dull green above, pale beneath, obscurely ciliate toward tip or glabrous, narrowly pale-margined; pedicels obsolescent, bearing about 2 pairs of bracts, the uppermost pair suborbicular, 2 mm. long, finely ciliate; ovary glabrous, 1.5-2 mm. long, the calyx limb 1.5 mm. long, the 4 teeth deltoid, acuminate, glabrous; corolla apparently white, depressed-subglobose with broad mouth, 3 mm. long in natural position (4 mm. when teeth are erected), 3.3 mm. thick, the 4 spreading deltoid acute teeth 1.5 mm. long, nearly 2 mm. wide at base; stamens 8, 2 mm. long, the broad glabrous filaments 0.6 mm. long, the anthers 1.6 mm. long (the sacs 0.5 mm. long, the tubules conic, 1.1 mm. long, the slits 0.5-0.6 mm. long).

COLOMBIA: Edge of bog, "Balsillas," on Río Balsillas, Dept. Huila, alt. 2100-2200 m., 3-6 Aug. 1917, *H. H. Rusby & F. W. Pennell* 827 (TYPE no. 1,041,504, U. S. Nat. Herb.; duplicate in Gray Herb.).

In habit and foliage this species closely agrees with the figure of *D. acuminatum* (H. B. K.) Niedenzu. Kunth did not himself see the flowers of that species, but they are described by Weddell, evidently from specimens of the original collection, since no other is cited. According to Weddell the filaments are pilose and about equal the anthers, and the tubules are slightly longer than the anther sacs, characters very different from those shown by the stamens of *D. elassanthum*.

Disterigma leiopodandrum Blake, sp. nov.

Undershrub; branches spreading-hirtellous; leaves elliptic to ovate-elliptic, small, acuminate to a usually obtusish apex, glandular-serrulate; pedicels solitary, 2-11 mm. long, bearing 2 or 3 pairs of bracts, the uppermost orbicular, equaling the ovary at anthesis; calyx lobes deltoid; corolla obovoid-urceolate, 7 mm. long, glabrous except for a few glands outside toward apex; filaments glabrous, 5.2 mm. long, the anthers 2.2 mm. long, the tubules slightly shorter than the sacs.

Caespitose undershrub, fastigiately branched, about 10 cm. high, very leafy; petioles broad, 0.5 mm. long; leaf blades 4.5-6 mm. long, 1.2-2.6 mm. wide, cuneate at base, pale green, coriaceous, often boat-shaped, glabrous above or sparsely hirtellous at base of blade, bearing a few appressed often dark-tipped elongate glands beneath, the lateral veins about 3 pairs, evident or obsolete beneath; flowers solitary, axillary; pedicels spreading-hirtellous, variable in length; uppermost pair of bracts obscurely ciliate, 3 mm. long, at first equaling or slightly exceeding the ovary, soon surpassed by it; ovary glabrous, 2 mm. long, about equaled by the calyx limb, the 4 teeth deltoid, acute, 1.2 mm. long, obscurely or not ciliate; corolla obovoid-urceolate, 7 mm. long, about 3.5 mm. thick (as pressed), deep red, above bearing a few subglandular hairs, the 4 teeth triangular, 0.8 mm. long, erect; stamens 8, 7 mm. long, the filaments 5.2 mm. long, glabrous or with about four hairs toward middle, the anthers 2.2 mm. long (the sacs 1.2 mm. long, the broad tubules 1 mm.); berry "white;" seeds obovoid, ridged on one side, foveate, brown, 1.2 mm. long.

COLOMBIA: In wet sphagnum on paramo, "Llano de Paletara," Cordillera Central, Dept. El Cauca, alt. 2950-3100 m., 15-17 June 1922, *F. W. Pennell* 6928 (TYPE no. 1,143,622, U. S. Nat. Herb.).

Of the *D. empetrifolium* group, and distinguished particularly by its nearly or quite glabrous filaments.

Disterigma codonanthum Blake, sp. nov.

Shrubby; branchlets spreading-hirtellous; leaves elliptic, small, obtusely acuminate, glandular-serrulate; flowers axillary, solitary, subsessile, bracts equaling or at first surpassing the ovary; corolla campanulate, about 7 mm. long, glabrous; stamens shortly exserted; filaments hirsute, 4.2 mm. long, the anthers 3.2 mm. long, the tubules shorter than the sacs.

Apparently low, fastigiately branched, very leafy; petioles broad, 0.5 mm. long; leaf blades 6-8 mm. long, 1.5-2.5 mm. wide, cuneate-rounded at base, glabrous above, sparsely dark-glandular beneath, coriaceous, pale green, the lateral veins 1-2 pairs, often evident beneath; pedicels about 1 mm. long, bearing about 2 pairs of bracts, the uppermost pair (subtending the ovary) suborbicular, many-nerved, 3.5 mm. long, obscurely ciliate; ovary glabrous, about 2.5 mm. long, the calyx limb 3-3.5 mm. long, its 4 teeth about 2.6 mm. long, 1.5 mm. wide at base; corolla (red ?) 7 mm. long (with teeth erected), about 5 mm. thick, glabrous, the 4 teeth deltoid, reflexed, 3 mm. long and wide; stamens 8, 6.8 mm. long, the filaments 4.2 mm. long, spreading-hirsute except toward base, the anthers 3.2 mm. long (the granulose sacs 2 mm. long, the rather definitely distinguished tubules 1.2 mm. long, the linear-elliptic pores 0.7 mm. long).

ECUADOR: Ecuadorian Andes, 1857-9, *R. Spruce* 5138 (TYPE in Gray Herb.; photograph and fragment, U. S. Nat. Herb.).

The type was distributed as a *Vaccinium*, under a manuscript name that has since been used in that genus for another species. *D. codonanthum* is distinguished from all except *D. pernettyoides* (Griseb.) Niedenzu by its broadly campanulate corolla. In *D. pernettyoides* the corolla is considerably larger (1-1.3 cm. long), the stamens are not exserted, and the tubules are longer than the anther sacs.

***Disterigma pentandrum* Blake, sp. nov.**

Undershrub; branchlets spreading-puberulous; leaves ovate to elliptic, small, obtuse, entire, thick and essentially veinless, marginate; flowers axillary, solitary, subsessile, 5-merous; bracts slightly surpassing ovary, oval-ovate, acutish, ciliate; calyx segments triangular, considerably longer than ovary, glandular-ciliate; corolla cylindric-urceolate, 10 mm. long, sparsely glandular outside above; stamens 5, the filaments 3.2 mm. long, pilose, the anthers 5.2 mm. long, the tubules somewhat exceeding the sacs.

Branches up to 28 cm. long, finely gray-puberulous, leafy; petioles 1 mm. long or less; leaf blades 7-12 mm. long, 4-7 mm. wide, obtuse or rounded, rounded at base, fleshy-coriaceous, strongly wrinkled on both sides when dry but without definite veins, glabrous, light green above, pale or brownish beneath, with thickened pale margins; pedicels obsolescent, bearing about 3 pairs of crowded bracts, the uppermost (subtending the ovary) 2.2 mm. long, ovary about 1.8 mm. long, (3- or) 5-celled, glabrous; calyx limb 2.8 mm. long, the 5 lobes triangular, acuminate, 2.2-2.6 mm. long, 1 mm. wide at base, erect, corolla (reddish ?) 10 mm. long, 3 mm. thick, fleshy, glabrous inside, the 5 erect triangular-oblong obtuse teeth 1.8 mm. long; stamens 7.8 mm. long; filaments not at all connate, pilose inside except toward the broadened base; anther sacs 2.4 mm. long, passing gradually into the conic tubules, these 2.5-2.8 mm. long, the slits 2.2-2.4 mm. long.

ECUADOR: Vicinity of Huigra, mostly on the Hacienda de Licay, 3 Sept. 1918, J. N. & G. Rose 22512 (TYPE no. 1,022,164, U. S. Nat. Herb.); vicinity of La Chonta, 16-17 Oct. 1918, Rose, Pachano, & Rose 23470.

In every character except its pentamerous flowers this plant is clearly a *Disterigma*, and since *D. ovatum* shows both 4- and 5-merous flowers (with 8 or 10 stamens), *D. pentandrum* may be received into the same genus. It is distinguished from all other species of the genus by its 5 stamens. In a flower of no. 23470 dissected the ovary was 3-celled, although the other floral parts were pentamerous. In Hördl's key to genera this species runs to *Oreanthes* Benth., because of its 5 stamens. In that monotypic genus the filaments are connate into a tube, and the corolla is described as 10 lines long.

DISTERIGMA DENDROPHILUM (Benth.) Niedenzu.

Vaccinium dendrophilum Benth. Pl. Hartw. 219. 1846.

Disterigma dendrophilum Niedenzu, Bot. Jahrb. Engler 11: 224. 1889.

Vaccintopsis tetramera Rusby, Descr. New S. Amer. Pl. 77. 1920.

The unique type of *Vaccintopsis tetramera* in the Columbia University Herbarium, sent for examination by the kindness of Dr. N. L. Britton, appears to belong to *D. dendrophilum*. The type collection of that species (Hartweg 1204) has not been examined, but *Spruce* 5403 (in the Gray Herbarium), distributed under that name, is evidently the same as Rusby's plant, although the anthers are longer. *Rusby* 2026, from Bolivia, is identical with the type of *V. tetramera*, and inseparable from *Spruce* 5403.

Disterigma pachyphyllum (Hemsl.) Blake.

Vaccinium pachyphyllum Hemsl. Biol. Centr. Amer. Bot. 2: 275. 1881.

This Costa Rican species is related to *D. alaternoides* (H. B. K.) Niedenzu, and Hörold's record of that species from Central America doubtless refers to it.

Disterigma ovatum (Rusby) Blake.

Vacciniopsis ovata Rusby, Bull. Torrey Club 20: 434. Pl. 170. 1893.

The flowers in this species, the type of the genus *Vacciniopsis*, are both 4- and 5-merous on the same specimen, and the plant is clearly a member of the genus *Disterigma*. Its closest ally is *D. popenoei* Blake, of Ecuador, which has more strongly 3-nerved leaves, more numerous flowers (about 6 in a fascicle), narrower white corollas rather densely spreading-puberulous outside, and different stamens. In *D. popenoei* the filaments are 5 mm. long and pilose on both sides except toward base, the anther sacs are 1 mm. long, and the tubules 2 mm. In *D. ovatum* the filaments are 2.8 mm. long, pilose only above the middle, the anther sacs 1.5 mm. long, and the tubules 1.7 mm. In Dalla Torre & Harms' Index, *Vacciniopsis* is placed in a different tribe (*Thibaudieae*) from *Disterigma*. It is not mentioned in Hörold's revisionary treatment of the American representatives of that tribe.

BOTANY.—*Tetrastylis*, a genus of *Passifloraceae*.¹ ELLSWORTH P. KILLIP, U. S. National Museum.

Tetrastylis, a genus of *Passifloraceae*, was established by Barbosa Rodrigues² in 1882, and to it was assigned a single Brazilian species, *Tetrastylis montana* Barb. Rodr. The description of the plant was very complete, and was accompanied by an excellent illustration. The principal points of difference between this genus and its nearest relative, *Passiflora*, as noted by Barbosa, were:

TETRASTYLIS

1. Four styles.
2. Gynophore curved.
3. Stamen filaments united beyond gynophore, only the extremities free.
4. Four placentae.

PASSIFLORA

1. Three styles.
2. Gynophore straight.
3. Stamen filaments free from gynophore to extremities.
4. Three placentae.

In the *Natürlichen Pflanzenfamilien*³ Harms recognized *Tetrastylis* as a valid genus, placing it immediately before *Passiflora*. In the *Index Kewensis* it was given as a synonym of *Passiflora* and *Tetrastylis montana* was identified with *Passiflora ovalis*, a plant figured by

¹ Published by permission of the Secretary of the Smithsonian Institution. Received May 17, 1926

² Rev Engenharia 4: 290. 1882.

³ P. 86. 1894.

Velloso in the Flora Fluminensis. In the first supplement to the *Natürlichen Pflanzenfamilien*⁴ Harms created the section *Tetrastylis* in the genus *Passiflora* for this plant. Several collections of this species have been made, and these have generally been distributed as *P. ovalis* Vell.

A few years ago several specimens of a Costa Rican plant, collected by Mr. H. Pittier, were distributed by the Instituto Físico-Geográfico Nacional of Costa Rica under the name *Passiflora adenopoda* DC. The specimens resemble *P. adenopoda* only in general leaf shape; the structure of the flower is essentially identical with that of *Tetrastylis*, that is, there are four styles, four placentae, and a curved gynophore, and the stamens are monadelphous *beyond* the gynophore. Several specimens of this same plant have recently been collected in Costa Rica by Mr. Paul C. Standley. This Costa Rican material represents a species, apparently undescribed, closely related to the Brazilian plant of Barbosa Rodriguez. The four details mentioned above seem to the writer of generic, rather than subgeneric, importance, and *Tetrastylis* should undoubtedly be maintained as a distinct genus.

A plant from Siam recently described by Gagnepain⁵ as *Passiflora octandra* is said to have 3, or often 4, styles, 3, or often 4, placentae. Other unusual features are four or five sepals, four or five petals, and six or eight stamens. Except for this plant, which may well represent a distinct genus, and the two species of *Tetrastylis*, the writer knows of no plants of this relationship with four styles and placentae.

A description of *Tetrastylis* and the two known species follows:

Tetrastylis Barb. Rodr. Rev. Engenharia 4: 260. 1882.

Passiflora Sect. *Tetrastylis* Harms, Nat. Fam. 1. Aufl. 1. Nactr. 256. 1897

Shrubby or herbaceous vines, bearing simple, axillary tendrils; stipules present; leaves alternate, petiolate; flowers in axillary racemes, or solitary or in pairs in the axils of the leaves, flower tube short, patelliform; sepals 5; petals 5, alternate with the sepals, inserted at the margin of tube; corona filamentose; operculum membranous, gynophore elongate, curved; stamens 5, the filaments united beyond gynophore into a broad membrane, only the extremities free, monadelphous; anthers oblong, bifid at base; ovary oblong, stipitate, obtusely 4-angled; ovules 4-ranked on 4 parietal placentae.

KEY TO SPECIES

Flowers in axillary racemes; leaves entire, coriaceous; stipules filiform, soon deciduous; petioles glandular at base; woody vine (Brazil) 1. *T. ovalis*
Flowers solitary or in pairs in the axils of the leaves; leaves 3-lobed, membranous; stipules semi-ovate, persistent; petioles glandular at middle; herbaceous vine. (Costa Rica) ... 2. *T. lobata*

⁴ P. 256. 1897.

⁵ Bull. Mus. Hist. Nat. Paris 25: 128. 1910.

1. *Tetrastylis ovalis* (Vell.) Killip, comb. nov.

Passiflora ovalis Vell. Fl. Flumin. 9: pl. 75. 1827 (figure only); M. Roemer, Fam. Nat. Syn. 2: 168. 1846.

Passiflora silvestris Mast. in Mart. Fl. Bras. 13¹: 620. pl. 127. 1872, not *Passiflora silvestris* Vell.

Tetrastylis montana Barb. Rodr. Rev. Engenharia 4: 260. 1882.

Woody vine; glabrous throughout, stems terete, longitudinally sulcate, suberose below; stipules setaceous, 8 to 10 mm. long, soon deciduous; petioles 2.5 to 4 cm. long, biglandular at base, the glands orbicular, about 1.5 mm. in diameter, sessile; leaves elliptic or elliptic-oblong, 6 to 10 cm. long, 3 to 5.5 cm. wide, not lobed, abruptly acuminate at apex, acutish at base, entire, usually cartilaginous at margin, 1-nerved (principal secondary nerves 7 or 8 pairs, arcuate), conspicuously reticulate-veined, coriaceous, sublustrous; flowers in axillary racemes up to 75 cm. long, the peduncles short, about 1 cm. long, stout, 2-flowered, the pedicels 1.5 to 4 cm. long, articulate above middle; bracts and bractlets setaceous, 1 to 2 mm. long, soon deciduous; flower tube 3 to 5 mm. long; sepals oblong, 2.5 to 3 cm. long, 0.5 to 0.7 cm. wide, obtuse, eocorniculate, subcoriaceous, dull red without (when dry), paler within, longitudinally streaked with red; petals oblong or lance-oblong, 1.5 to 2 cm. long, 0.3 to 0.5 mm. wide, obtuse, membranous, whitish, longitudinally streaked with red both without and within; corona filaments narrowly liguliform, in 2 series, the outer about 1 cm. long, the inner half as long, operculum membranous, closely plicate, incurved, crispate; limen annular, fleshy; gynophore about 2 cm. long; ovary oblong; fruit (according to Velloso) oblong, about 10 cm. long, 6 cm. wide; seeds obovate, truncate at apex.

Specimens examined (all Brazil):

Rio de Janeiro, *Glaziou* 7859 (Paris, Berlin, Copenhagen), 8269 (Berlin, Copenhagen), 14854 (Paris, Berlin, Geneva, Kew, Copenhagen), 14873 (Paris), *Peckholt* 7 (Berlin); *De Moura* 503 (Berlin). Bahia, *Blanchet* 1708 (British Museum). Without definite locality, *St. Hilaire* 1689 (Paris).

The nomenclature pertaining to this species is somewhat involved. Velloso's figure was unaccompanied by any description or explanatory notes, and under the rules of nomenclature does not constitute valid publication. Roemer, however, in his elaborate monograph of Passifloraceae, gives a detailed description of Velloso's plate, and the species must be considered to date from this publication in 1846. Masters' treatment of the species in the *Flora Brasiliensis*¹ is a curious one. Here species no. 77 is given as "*Passiflora silvestris* Vell." and Velloso's plate 74, bearing this name, is cited. The description which Masters then gives of this species applies in general, however, to Velloso's plate 75 (*P. ovalis*), and the figure with which Masters illustrates "*Passiflora silvestris*" (plate 127) agrees almost exactly with Velloso's *P. ovalis*, and bears no resemblance to the plate of *P. silvestris* of Velloso. The inflorescence as shown by Masters' plate is an elongate raceme with 2-flowered peduncles, and the leaves are narrowed at the base, with the petioles biglandular. The detailed enlargement of the flowers shows four styles but a straight gynophore with the staminal structure as in true *Passi-*

¹ 13¹: 620. pl. 127. 1872.

flora This conventionalized flower sketch I believe was made from two different plants, one true *Tetrastylis ovalis*, the other some unknown species of *Passiflora* of the *Cranadilla* relationship This solution is also suggested by the specimens which Masters cites under his "*Passiflora silvestris*" The first mentioned is "Velloso," the specimen not being seen by Masters The second is "Luschnath" This specimen I did not see at any of the European herbaria visited, and at Kew it is represented only by a sketch of the flower This has three styles and a straight gynophore Accompanying the sketch is a note by Masters "P. *silvestris* St Hil?" The third specimen cited is "Prov Minas Geraes, St Hilaire 1689" This specimen, which I saw at Paris, is *Tetrastylis ovalis*

Finally, as to "*Passiflora ovalis* Vell" Masters merely lists this among certain doubtful species, stating that only a fruiting specimen was figured

The identity of *Passiflora silvestris* Vell (plate 74) I have not fully established It represents a plant closely related to *Passiflora juleki* Wawra if not that species

2 *Tetrastylis lobata* Killip, sp nov

Stem stout, triangular, grooved, glabrous, stipules in pairs, semi-ovate, 5 to 15 mm long, 3 to 8 mm wide, aristate, entire petioles 3 to 8 cm long, canaliculate above, hispidulous, bearing near middle 2 subsessile saucer-shaped glands, a second pair occasionally present at base of blade, the glands 1 to 2 mm in diameter, leaves 10 to 15 cm long (along midnerve), 12 to 20 cm wide (between apices of lateral lobes), 3-lobed half to two-thirds the length of the blade (lobes variable, oblong, oblong-lanceolate, or broadly ovate-lanceolate, 2.5 to 6 cm wide, acuminate or acute), cordate, 3-nerved, entire or slightly undulate, membranous, dark green and minutely hispidulous with hooked hairs above, glabrous, (occasionally slightly scabrous), and mottled with dull dark red beneath, peduncles solitary or in pairs, 2 to 3.5 cm long, glabrous or sparingly hispidulous, bracts setaceous, 2 to 3 mm long, borne on lower half of peduncle, flowers 3.5 to 6 cm wide, the tube patelliform, about 3 mm long, sepals oblong-lanceolate, 1.5 to 2.5 cm long, 0.4 to 0.8 cm wide, sparingly hispidulous and green without, glabrate and white, or pale rose, streaked longitudinally with violet within, terminating in a horn about 2 mm long, petals ovate-lanceolate, 0.8 to 1.5 cm long, 0.5 to 0.7 cm wide, obtuse, streaked longitudinally with violet on both faces, corona filaments in a single series, filiform, narrowly ligulate, 1 to 2 cm long, operculum membranaceous, deep red, strongly plicate, incurved up to 5 mm high, minutely denticulate, nectar ring annular, less than 0.5 mm high, lumen membranaceous, 1 to 2 mm high, incurved, crenulate, gynophore about 1 cm long, stamens united to within 3 mm of their tips, forming a membranous androecium, the upper portion free from the gynophore, about 2.5 mm long, the lower portion closely sheathing the gynophore, ovary narrowly ovoid, obtuse, tapering at base, glabrous, styles clavate, 4.5 mm long, recurved, stigmas saucer-shaped, fruit obovoid, about 10 cm long, 3 cm in diameter, green, white-spotted, seeds obovate

Type in the U S National Herbarium, no 1,251,085, collected at La Hondura, Province of San José, Costa Rica, altitude 1200-1500 meters, March 9, 1926, by Paul C Standley (no 51917)

Additional specimens examined (all Costa Rica):

Finca de Chirripó, Plains of Zent, altitude 200 meters, *Pittier* 16055 (U. S. N. M., Brit. Mus.), 16100 (Brit. Mus.). Tilarán, altitude 750 meters, *Valerio* 14 (U. S. N. M.). Vicinity of Orosi, Province of Cartago, *Pittier* 16026 (U. S. N. M.); *Standley* 39673, 39720, 39793. Santa María de Dota Province of San José, *Standley* 41796. El Muñeco, on Río Navarro, Province of Cartago, *Standley* 51389. La Estrella, Province of Cartago, *Standley* 39352. Quebrada Serena, southeast of Tilarán, Province of Guanacaste, *Standley* 46140 (all U. S. N. M.).

Two of these specimens (*Pittier* 16055 and *Valerio* 14), have leaves less deeply lobed than are those of the type, and the pubescence is rather denser. The general appearance of *Standley*'s 46149 is quite different, the leaves drying a lighter green and the lateral lobes being much reduced. The flowers of all of the specimens here cited seem the same, and the differences in vegetative characters are no greater than in many species of the family.

This plant is not to be confused with *Ceratosesepalum micranthum* Oersted⁷ (later reduced to *Passiflora ceratosepala* Mast.). *Ceratosesepalum* was segregated from *Passiflora* mainly on the basis of horned sepals. Among several specimens of *Passifloraceae* sent me by the Universitetets Botaniske Museum, Copenhagen, for study were two sheets labeled "*Ceratosesepalum*" in Oersted's handwriting, which evidently are type material of *Ceratosesepalum micranthum*. They prove to be *Passiflora adenopoda* DC., a fairly common species ranging from Mexico to northwestern South America.

ANTHROPOLOGY. *The fundamental principles of Algonquian languages.*¹ TRUMAN MICHELSON, Bureau of American Ethnology.

The grammatical processes are prefixing, suffixing, reduplication of various types, vocalic change, and composition. All objects are classified as animate and inanimate. Singular and plural are distinguished; as also the first person plural exclusive and inclusive; difference and identity of third persons are carefully kept apart by grammatical devices. In the verb there are frequently two stems, and sometimes more. Of these those which under no circumstances can occur in the initial position are very few in number. When two stems, both of which can occur in the initial position, are combined in a single compound, it is quite conventional as to which precedes or follows. The phonetic changes resulting from such combinations are relatively few and are of a simple character. It should be noted that a number of stems indicating parts of the body occur in the second position only.

⁷ OERSTED, Rech. Fl. Amer. Centr. 18 pl. 17. 1863.

¹ Summary of an address given before Section L of the American Association for the Advancement of Science, January 3, 1925. Received May 26, 1926.

And it should be stated that the auxiliaries are few in number and occur in the second position only, and frequently are entirely distinct according to whether the subject is animate or inanimate. The number of moods is very great. The subject pronouns of the independent mood are clearly related to, and in some cases are identical with, the possessive pronouns, and are partly prefixed, partly suffixed, partly both. Some of the objective pronouns of the independent mood are the same as some of the subordinate moods, and are suffixed. The inclusive form in this mood (and others) is clearly related to the second person plural. The forms of the independent mood with the third person animate, singular and plural, as subjects and the first and second person singular, the inclusive and exclusive, and the second person plural as objects are really passives in construction. All the pronouns of the subordinate moods are invariably suffixed. The objective pronouns are largely the same in the various subordinate moods while several of the subjective pronouns are fundamentally different. Yet in many cases the objective and subjective pronouns are so fused, and at times even modal elements with them, that analysis into the constituent elements is not possible. A participial is formed by changing the stem vowel of the first vowel of the initial stem; the pronominal elements in this case are obviously derived from other sources with but slight changes. The complexities of this mood, however, have not been thus far adequately treated. The following voices are distinguished: active, middle, passive, reflexive, and reciprocal. The last two are formed by special suffixes, but the ordinary intransitive verbal pronouns are used. At least two passives are common, one where the agent is either expressed or understood, the other where the agent is not expressed and is indefinite. The pronominal elements of the last, in the case of the independent mode, are allied partially to the ordinary intransitive verbal pronouns. Other passives apparently exist, but their exact function is not accurately known. One appears to be very indefinite and to occur only with an indefinite subject. Every active, middle, and passive verb (with a few exceptions) requires an instrumental particle showing by what the action was done, e.g., by the hand, by the foot, by heat, by cutting, etc. The middle voice employs the ordinary intransitive verbal pronouns with these particles. From what has been said it is clear that in some Algonquian languages the verbal pronominal elements theoretically must run into the thousands. These instrumental particles are comparatively few in number (in Fox about forty), and

usually differ in form according to whether the logical object is animate or inanimate; in the case of the middle voice the subject (animate or, rarely, inanimate) determines the choice. It should be noted that often these particles are purely formal, having lost their original significance; in such cases it must be known by rote as to which sets go with any given verbal stem. The instrumental particles can be combined with initial stems, and follow them if there is no second stem; if there is a second stem (whether wholly non-initial or one that may occur in the initial position in another verbal compound), they follow this. The typical Algonquian verb in subordinate moods would be: first stem, second stem, instrumental particle, objective pronoun, subjective pronoun, modal element. Temporal relations in some dialects are expressed by what for convenience may be termed prefixes, though there are indications that some are strictly not these, in others by combining initial stems. Reduplication of various types occurs, to express ideas of intensity, duration, distribution. When the whole stem is not reduplicated, a long *i* of the first syllable of the initial stem (which alone can be reduplicated) is replaced by *ä*; under similar conditions *ö* also by *ä*. The structure of nouns follows the general arrangement of verbs, but there are some suffixes with generic meanings. It may be added that abstract nouns are extremely common. A general, vocative, locative, and obviative (and in some dialects a sur-obviative) case are distinguished. The independent pronouns are patently related to the possessive pronouns. The demonstrative pronouns express such ideas as near and visible, removed but visible, past time, etc. What has been said above applies especially to the Eastern-Central dialects; Blackfoot and Arapaho have specialized in opposite directions; so we may be sure that neither presents a primitive Algonquian grammar. Secondary phonetic changes and some specializations have in some instances obliterated the principles enunciated above in certain of the Eastern dialects; but in almost all cases we may show by comparative methods what originally existed.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

938TH MEETING

The 938th meeting was held at the Cosmos Club on Saturday evening, April 17, 1926. The meeting was called to order by Vice-President AULT at 8:15, with 32 persons in attendance.

The program for the evening consisted of two papers. The first by H.

L. DRYDEN was on the *Measurement of the performance of desk fans*, and was discussed by Messrs. BREIT, DICKINSON, PAWLING, TUCKERMAN and HUMPHREYS.

The common method of measuring the output of desk and bracket type electric fans consists in the measurement of the velocity distribution along one or more diameters by means of a Pitot tube and inclined gauge or equivalent device, the results being integrated to give the total volume of air flowing. These measurements were shown to be subject to a systematic error due to the angular inclination of the airflow to the Pitot tube. A general description was given of the type of airflow and of the principles involved in the cooling action of the fan. Various quantities which have been suggested as measures of the output were discussed, including volume per unit time, momentum per unit time, and energy per unit time. As a result the momentum per unit time was suggested as the best criterion of cooling power since (1) it is sensibly constant at all distances from the fan; (2) it is a satisfactory compromise between several theoretical considerations; and (3) it is readily and accurately measurable by the thrust reaction on the fan. Methods of measurement of the thrust were described and a particular form of instrument was suggested for convenient use. (*Author's abstract.*)

The second paper on the program was by W. W. COBLENTZ on *Impressions of the Sumatra eclipse expedition*, and was illustrated by lantern slides. It was discussed by Messrs. HUMPHREYS and AULT.

The speaker was one of a party of four, under the leadership of Dr. H. T. Stetson of the Astronomical Laboratory, Harvard University, that went to Sumatra to observe the solar eclipse of January 14, 1926. Leaving San Francisco in November, 1925, after spending a month in the eclipse camp at Benkoelen, Sumatra, they returned by way of the Suez Canal and Europe in March, 1926.

After discussing various factors that affect eclipse observations the speaker exhibited an extensive series of lantern slides of scenes along the route as well as in the eclipse camp.

There were eight expeditions in the field to make observations on the solar eclipse; one on the east coast of Sumatra, one in the center of the island, and six in Benkoelen on the west coast. Only the latter expedition had good weather during most of the time of totality.

In view of the numerous factors that enter into the success of such an undertaking (the weather, and health of the members, unforeseen accidents, etc.), it seems desirable to consider the results obtained by all the parties concerned, as a whole; and when so judged the results obtained were a success.

The Harvard-Bureau of Standards eclipse party had six projects; including thermopiles for measuring the radiation of the corona, a lumenometer for measuring the brightness at totality, a silvered quartz lens camera for photographing the corona in ultra light, and two photographic methods for obtaining the color index. The lumenometer measurements show that the normal illumination at totality was brighter than that of the eclipse of January 24, 1925.

The speaker had an opportunity to study the native fireflies and glow worms in Sumatra, and vegetation on the moving sands in Egypt, the latter being of interest in connection with the question of variation in coloration on the surface of Mars. Unusual phenomena, such as the "green flash" at sunset, and the sheen over the ocean from the zodiacal light, were commented upon in concluding the address. (*Author's abstract.*)

An informal communication on *Gravity variations due to the moon* was presented by Mr. A. S. HAWKESWORTH.

939TH MEETING

The 939th meeting was held at the Cosmos Club on Saturday evening, May 1, 1926. The meeting was called to order by President BOWIE at 8:16, with 31 persons in attendance.

The program for the evening consisted of two papers. The first by W. J. PETERS was entitled *The 27-day interval in earth currents*. It was illustrated, with lantern slides and was discussed by Dr. BAUER.

Dr. Chree and others have shown by statistical investigations the recurrence of average high and average low values on the 27th day after days of selected maximum and minimum in long unbroken records of magnetic measures, such as the international character numbers, the daily ranges in magnetic elements. The high correlation found by Dr. Bauer between the variations, in terrestrial magnetism, atmospheric electricity, and earth-currents indicates the desirability of applying the same statistical method of investigating the 27 day recurrency to those related phenomena.

The subject of this paper is a description of the process as applied to the earth-current observations published in the bulletins of Ebro Observatory in Spain between 1910 and 1924 inclusive and the exhibition of the results.

The daily ranges in the potential of the northerly-extending line, expressed in millivolts per kilometer were transferred by adding machine to strips of paper, the values for each day following one another in regular order without any intermissions excepting the missing observations. According to the usual practice the 5 highest and the 5 lowest values of each month were selected and the particular day on which each value occurs was designated n . They were marked on the strips, after which it became a simple matter to pick out by means of a device designed by Mr. C. C. Ennis the values that occur on any day desired, the $(n + r)$ th day, following or preceding the days, n th days, on which the selected values occur.

The values of r were taken from -2 to $+2$ inclusive, in order to bring out the mean character of the selected maximum or minimum values, and from $+23$ to $+32$ inclusive not only to show the character of corresponding mean values on and around the 27th day but also to develop any other recurrency interval that might exist within these limits.

Results were given for the following periods: 1910-1914, which covers the earliest published records of the Observatory; 1915-1919, which includes the year of sunspot maximum, 1917, and the year of magnetic maximum, 1919; 1922-1924, which covers the period after the intermission of one year, 1921, during which the apparatus was overhauled, up to the most recent published results; 1910-1920, which covers the period of another investigation; and 1910-1924, which includes all data available. The paper will appear in *Terrestrial Magnetism*. (Author's abstract.)

The second paper was by E. O. HULBURT on *The spectrum of hydrogen in the stars and in the laboratory*. It was illustrated with lantern slides, and was discussed by PAWLING, BREIT, LAPORTE, and HUMPHREYS.

The Balmer series of hydrogen, the simplest series of the simplest of terrestrial elements, finds its most striking development in the spectra of the stars and in the "flash spectrum" of the sun. As many as thirty to thirty-five lines of the series are observed in the light from these extra-terrestrial sources. The characters of the lines themselves vary greatly

in the different spectra, being bright (emission), dark (absorption), narrow, broad, singly, doubly and triply reversed, etc. The production of these lines and their variations with the relatively weak apparatus of the terrestrial laboratory has been accomplished only in part. The laboratory investigations have, however, contributed definite knowledge of the physical conditions in the stellar atmospheres, and further investigations offer great promise.

The laboratory observations of the emission series to the twentieth Balmer line and of the absorption series to the tenth line indicate that great expanses of glowing hydrogen at low pressures are necessary for the full development of the series as seen in the stellar spectra. The Balmer lines broaden very greatly with pressure, current density, foreign gases, etc. Studies of the intensity distribution across the individual broadened lines have led to the conclusion that the broadening is caused by the electric fields of the ions and electrons of the radiating gas. This theory of broadening is applied to the wide hydrogen lines of the stars. From the observed widths of these together with the Saha theory of temperature ionization the conclusions are indicated that the pressures in the stellar reversing layers are low and that there may be many electrons in these layers.

Doubly reversed Balmer lines are observed in the laboratory, but as yet no triple reversals. Stellar atmospheres which give rise to the double and triple reversals may be pictured with some certainty. The cause of the asymmetric reversals observed in some stellar spectra can not be said to be definitely known. (*Author's abstract.*)

H. A. MARMER, *Recording Secretary.*

ANTHROPOLOGICAL SOCIETY

596TH MEETING

At the 596th meeting of the Anthropological Society on March 16th, W. H. JACKSON, photographer to the Hayden Geological Surveys, 1870-79, reviewed his experiences of fifty years ago among cliff ruins and Pueblo villages in Colorado and New Mexico, illustrating his subject with slides from original photographs. While engaged in photographing in the San Juan Mountains, in 1874, a chance meeting with prospectors who told of some wonderful cliff dwellings not far from their camp on the Rio La Plata led to the discovery, or more properly the first published account, of the Mesa Verde ruins. (Letter to the New York Tribune, November 3d by Ernest Ingersoll.) Following their advice that something worth while might be found in that region, Mr. JACKSON left his main party in camp at Baker's Park and with Mr. INGERSOLL, and two packers, made a hasty side trip to the miners' camp where he met JOHN MOSS, who had traveled extensively over the southwest and who volunteered to guide the party through Mancos Canyon in the Mesa Verde, where he said the best examples of ancient cliff dwellings were to be found. On a six day ride taking in the Mesa Verde, the McElmo canyon, and the Hovenweep valley, many of these ruins were discovered and photographed, but the greatest and most interesting group of all, now the main feature of the Mesa Verde National Park, was not discovered until fourteen years later. The results of this first expedition among the cliff dwellings were of such interest that exploration was continued the following year into Utah and Arizona. Mr. W. H. HOLMES also led a party into this region, which, while primarily engaged in geological work, devoted much time to archeological research, paying particular attention to the towers of the San Juan Valley. Mr. JACKSON's party followed the San Juan

River to the Chinle, and thence to the Hopi pueblos. Returning northwards they visited the Abajo and LoSal Mountain region and then followed the Montezuma Canyon back to the starting point. Many interesting cliff, cave, and town ruins were discovered and photographed, including nearly every canyon, mesa or valley throughout the whole region containing evidences of prehistoric occupation. The Southern Utes, as well as tribes farther west, were troublesome this year, Mr. GARDNER's topographical party being attacked near the Abajo Peaks by a large party, with the loss of three animals and all his camp equipment. Mr. HOLMES' party came near losing all its animals, and Mr. JACKSON also had frequent encounters, but without loss. In 1877 an extended trip was made through New Mexico to the Hopi pueblos in Arizona, during which Mr. JACKSON made a detailed study of the Chaco Canyon ruins, and with the reports which followed, concluded his archeological work for the Survey.

SCIENTIFIC NOTES AND NEWS

Dr. WILLIS T. LEE, geologist of the United States Geological Survey, known to the public through his recent scientific studies and surveys of the Carlsbad and other noted caverns of the country, died at his home in Washington on June 17, in his sixty-second year.

Dr. T. A. JAGGAR, director of the Hawaiian Volcano Observatory of the U. S. Geological Survey, gave an illustrated lecture at the Interior Department on June 12 on *The recent eruption of Mauna Loa*.

Dr. N. L. BOWEN of the Geophysical Laboratory, Carnegie Institution of Washington, sailed for England on June 5, to spend the summer in field work on the igneous rocks of the British Isles, in company with several British petrologists.

JOHN W. VANDERBILT, S. SPENCER NYE and MARTIN J. BUERGER have been appointed junior geologists in the U. S. Geological Survey and have been assigned field work in the west.

B. S. BUTLER and T. S. LOVERING of the U. S. Geological Survey have been assigned to the State of Colorado to begin cooperative geological surveys in that State designed to aid in the development of its metalliferous mineral resources. The research may extend over a number of years.

The new officers of the American Geophysical Union as elected for the period July 1, 1926 to June 30, 1929, at the annual meeting of the Union in April last, are: Chairman, H. S. WASHINGTON; Vice-Chairman, G. W. LITTLEHALES. (J. A. FLEMING continues as General Secretary through June 30, 1928.) The newly elected officers of sections for the corresponding period are: (a) Geodesy—Chairman, WILLIAM BOWIE; Vice-Chairman, F. E. WRIGHT (W. D. LAMBERT continues as Secretary through June 30, 1928); (b) Seismology—Chairman, L. H. ADAMS; Vice-Chairman, N. H. HECK (D. L. HAZARD continues as Secretary through June 30, 1928); (c) Meteorology—Chairman, H. H. KIMBALL; Vice-Chairman, G. W. LITTLEHALES; Secretary, A. J. HENRY; (d) Terrestrial Magnetism and Electricity—Chairman, N. H. HECK; Vice-Chairman, J. H. DELLINGER; Secretary, J. A. FLEMING; (e) Oceanography—Chairman, T. WAYLAND VAUGHAN; Vice-Chairman, G. T.

RUDE; Secretary, AUSTIN H. CLARK; (f) Volcanology—Chairman, T. A. JAGGAR, Jr.; Vice-Chairman, F. E. WRIGHT (R. B. SOSMAN continues as Secretary through June 30, 1928).

The United States Geological Survey has established a Section of Volcanology in the Geologic Branch, effective July 1, of which T. A. JAGGAR, Jr., will be Volcanologist in charge.

Mr. KIRK BRYAN of the United States Geological Survey has been appointed Lecturer in Physiography at Harvard University for the year 1926-27.

N. L. WIMMLER has been appointed mining engineer and F. W. HOLZHEIMER associate mining engineer in the U. S. Geological Survey. They will make investigations in Alaska.

A. M. PIPER has been appointed assistant geologist in the Water-Resources Branch of the U. S. Geological Survey, and will be assigned to ground-water investigations.

H. D. MISER, who has been temporarily State Geologist of Tennessee since September 1, 1925, has returned to the U. S. Geological Survey and has been appointed Geologist in charge of areal geology, in the Geologic Branch, as successor to Sidney Paige, resigned.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 16

AUGUST 19, 1926

No. 14

MATHEMATICS.—*Transformations associated with the Lorentz group and their invariants.*¹ CHARLES BARAFF, U. S. Patent Office.
(Communicated by L. H. ADAMS.)

The aim of the scientist is duofold; first to describe the processes of flux in Nature by means of transformation equations, then to reveal amidst this continual change those entities that are immutable and unchangeable. In an address to the British Association for the Advancement of Science, MacMahon,² the president of Section A, called attention to this aim and emphasized its importance in the following words,

"In any subject of inquiry, there are certain entities, the mutual relations of which under various conditions it is desirable to ascertain. A certain combination of these entities may be found to have an unalterable value when the entities are submitted to certain processes or are made the subjects of certain operations. The theory of invariants in its widest scientific meaning determines these combinations, elucidates their properties and expresses results when possible in terms of them. The great principle of chemical science which asserts that when elementary or compound bodies combine with one another the total weight of the materials is unchanged, illustrates one case in point. Another illustration is a fundamental principle in physics,—that when a given mass of an ideal gas is under the operation of varying pressure and temperature the quantity $\frac{\text{pressure} \times \text{volume}}{\text{temperature}}$ is invariant."

With the advent of the theory of relativity in recent years with a scheme of transformations radically different from the transforma-

¹ Received February 19, 1926.

² Report Brit. Assoc. Adv. Sci. 1901.

tions of classical physics, the question naturally arises as to the nature of the invariant entities associated with it. The most fundamental invariant of this theory is the interval between two world events. Some other special invariants are the velocity of light through vacuum space and electric charge. It is the aim of this paper in continuation of the results presented in a former paper³ to elucidate some of the quantities and expressions that remain invariant to a special relativity transformation. The results are set down in a mathematical way with little or no comment. Their physical interpretation is reserved for a future paper.

In what follows most of the transformations are taken from Einstein's original paper of 1905 on the special relativity theory. The invariants are derived by the methods outlined in Wright's *Invariants of Quadratic Differential Forms*.⁴

The invariants which are derived constitute a set of independent invariants from which other dependent invariants may be derived by the ordinary processes of algebra and calculus.

The scheme of notation is as follows: the quantities accented are those that are observed by an observer moving uniformly relatively to a second observer, who represents the corresponding magnitudes by unaccented symbols.

All references to light include any radiation which is propagated through vacuum with the velocity c given by the ratio of the electromagnetic to the electrostatic unit.

1. KINEMATICAL TRANSFORMATIONS AND THEIR INVARIANTS

In the former paper⁵ the transformations for velocities and accelerations were given.

It may be noted that the most general function of the space time coordinates, that remains invariant to the transformation of space time coordinates is

$$F(x^2 - c^2t^2, y, z) \quad (1)$$

Similarly, the most general invariant function which involves velocities only is

$$F\left(\frac{\sqrt{c^2 - u_x^2}}{u_x}, \frac{u_y}{u_x}\right) \quad (2)$$

where F is any arbitrary function of the arguments.

³ This JOURNAL, 18: 81-87. 1926.

⁴ WRIGHT, *Invariants of Quadratic Differential Forms*. 1908.

⁵ *Op. cit.*

It may also be noted that the invariants of the accelerations are deducible as the solutions of the simultaneous equations

$$\frac{-du_x}{1 - \frac{u_x^2}{c^2}} = \frac{du_y}{u_x u_y} = \frac{du_z}{u_x u_z} = \frac{dw_x}{3u_x w_x} = \frac{dw_y}{2u_x w_y + u_y w_x} = \frac{dw_z}{2u_x w_z + u_z w_x} \quad (3)$$

There are five independent solutions, three of which are

$$\frac{\sqrt{c^2 - u_x^2}}{u_y}, \quad \frac{u_y}{u_x}, \quad \frac{w_x}{\left(1 - \frac{u_x^2}{c^2}\right)^{3/2}}.$$

The other two will follow from the complete integration of these equations. The form of

$$\frac{w_x}{\left(1 - \frac{u_x^2}{c^2}\right)^{3/2}}$$

is of interest, for it has the form of a space time curvature

$$\frac{\frac{d^2 x}{dt^2}}{\left(1 - \left(\frac{dx}{dt}\right)^2/c^2\right)^{3/2}} \quad (12)$$

In the theory of the radiation from electrons, it is sometimes necessary to go one derivative further and consider third derivatives of the space with respect to the time, or the time rate of change of acceleration, which is the equivalent. We will denote the derivative of the acceleration with respect to the time by the symbol K . Its component parallel to the X axis is transformed by means of the equation

$$K'_x = \frac{K_x}{\beta^4 \left(1 - \frac{v u_x}{c^2}\right)^4} + \frac{3 w_x^2 v}{\beta^4 \left(1 - \frac{v u_x}{c^2}\right)^4} \quad (13)$$

The invariant involving it, the acceleration and the velocity is

$$\frac{3 W_x^2 U_x - K_x \left(1 - \frac{u_x^2}{c^2}\right)}{\left(1 - \frac{u_x^2}{c^2}\right)^3} \quad (14)$$

This section will be concluded with the transformations for momenta G and Gibb's heat function R , which were deduced by Planck* from a combination of the *principle of least action* with the *principle of relativity*.

The transformations of these quantities are:

$$G'_z = \beta \left(G_z - \frac{v}{c} \frac{R}{c} \right) \quad G'_y = G_y \quad G'_x = G_x$$

$$\frac{R'}{c} = \beta \left(\frac{R}{c} - \frac{v}{c} G_z \right)$$

Here G denotes momenta, R denotes the Gibb's Heat Function under constant pressure

$$R = E + pV$$

where E denotes the total energy of the body, p the pressure acting on it, V its volume.

The fundamental invariant involving these two quantities G and R is:

$$\frac{R^2}{c^2} - G_z^2$$

or

$$\frac{(E + pV)^2}{c^2} - G_z^2$$

These transformations may be written in the equivalent form

$$\frac{R'}{c} + G'_z = e^{+i\theta} \left(\frac{R}{c} + G_z \right)$$

$$\frac{R'}{c} - G'_z = e^{-i\theta} \left(\frac{R}{c} - G_z \right)$$

and the invariant therefor in the form

$$\left(\frac{E + pV}{c} - G_z \right) \left(\frac{E + pV}{c} + G_z \right)$$

* PLANCK, *Ann. d. Physik*: 1 1903

II. ELECTRODYNAMIC TRANSFORMATIONS AND THEIR INVARIANTS

Electrodynamic quantities are transformed, according to the special theory of relativity, by means of the scheme of transformation identities:

$$\left. \begin{aligned}
 X' &= X & L' &= L \\
 Y' &= \beta \left(Y - \frac{v}{c} N \right) & M' &= \beta \left(M + \frac{v}{c} Z \right) \\
 Z' &= \beta \left(Z + \frac{v}{c} M \right) & N' &= \beta \left(N - \frac{v}{c} Y \right) \\
 \rho' &= \beta \left(1 - \frac{v}{c^2} u_x \right) \rho \\
 u'_x &= \frac{u_x - v}{1 - \frac{u_x v}{c^2}} \\
 u'_y &= \frac{u_y}{\beta \left(1 - \frac{u_x v}{c^2} \right)} \\
 u'_z &= \frac{u_z}{\beta \left(1 - \frac{u_x v}{c^2} \right)}
 \end{aligned} \right\} (1)$$

These symbols have the same significance and meaning that is ordinarily attached to them in the fundamental Maxwell-Lorentz equations:

$$\left. \begin{aligned}
 \frac{1}{c} \left(\frac{\partial E}{\partial t} + \rho u \right) &= \text{curl } H \\
 \frac{1}{c} \frac{\partial H}{\partial t} &= \text{curl } E \\
 \text{div } E &= \rho \\
 \text{div } H &= 0
 \end{aligned} \right\} (2)$$

The transformation identities for the electric and magnetic intensities may be exhibited in somewhat different form by letting

$$\theta = \tan^{-1} \frac{v}{c} = \cos^{-1} \beta$$

in which case, the equations have the form

$$\left. \begin{aligned} X' &= X \\ L' &= L \\ Y' &= Y \cos \theta + Ni \sin \theta \\ N' &= N \cos \theta + Yi \sin \theta \\ Z' &= Z \cos \theta - Mi \sin \theta \\ M' &= M \cos \theta - Zi \sin \theta \end{aligned} \right\} (3)$$

These equations may be derived by integrating the system of simultaneous differential equations

$$\frac{dX'}{0} = \frac{dY'}{-N'} = \frac{dZ'}{M'} = \frac{dL'}{0} = \frac{dM'}{Z'} = \frac{dN'}{-Y'} = \frac{c \, \delta \, v}{c^2 - v^2} \quad (4)$$

with the initial conditions that when $v = 0$, then

$$\begin{aligned} X' &= X \\ Y' &= Y \\ Z' &= Z \\ L' &= L \\ M' &= M \\ N' &= N \end{aligned}$$

There are five independent invariants of electric and magnetic intensity. They are

$$\left. \begin{aligned} X \\ L \\ Y^2 - N^2 \\ Z^2 - M^2 \\ \frac{YM + ZN}{MN + YZ} \end{aligned} \right\} (5)$$

The most general invariant function of electric and magnetic intensities is an arbitrary function of these, namely, the function

$$F\left(X, L, Y^2 - N^2, Z^2 - M^2, \frac{YM + ZN}{MN + YZ}\right) \quad (6)$$

As a special example of an invariant function of electric and magnetic intensities, it might be interesting to note in passing, the Lagrangian function

$$(X^2 + Y^2 + Z^2) - (L^2 + M^2 + N^2)$$

Let us consider now the transformation identities for ρ , u_x , u_y , u_z . The system of differential equations from which these may be derived by integration are

$$\frac{-du'_x}{1 - \frac{u'^2_x}{c^2}} = \frac{du'_y}{\frac{u'_x u'_y}{c^2}} = \frac{du'_z}{\frac{u'_x u'_z}{c^2}} = \frac{-d\rho'}{\frac{u'_x \rho'}{c^2}} = \frac{\delta v}{1 - \frac{v^2}{c^2}}$$

with the familiar condition that when $v = 0$ then

$$\rho' = \rho$$

$$u'_x = u_x$$

$$u'_y = u_y$$

$$u'_z = u_z$$

The independent invariants involving ρ , u_x , u_y , u_z only are

$$\left. \begin{aligned} &\frac{u_y}{u_x} \\ &\rho u_y \\ &\rho \sqrt{c^2 - u_x^2} \end{aligned} \right\} \quad (7)$$

The most general function of these which is invariant to the Lorentz transformation and the associated transformations above is:

$$F\left(\rho u_y, \frac{u_y}{u_x}, \rho \sqrt{c^2 - u_x^2}\right) \quad (8)$$

At this point, the question arises as to the form of the most general invariant function of the ten quantities that enter into the Maxwell-

Lorentz equations of electro-dynamics. There are nine independent invariants

$$\left. \begin{aligned} X \\ L \\ Y^2 - N^2 \\ Z^2 - M^2 \\ \frac{YM + ZN}{MN + YZ} \\ \frac{(N + Y)(c + u_x)}{(N - Y)(c - u_x)} \\ \frac{u_x}{u_z} \\ \rho u_y \\ \rho \sqrt{c^2 - u_x^2} \end{aligned} \right\} (9)$$

from which the most general invariant function is derived by taking an arbitrary function of these, to wit

$$F\left(X, L, Y^2 - N^2, Z^2 - M^2, \frac{YM + ZN}{MN + YZ}, \frac{(N + Y)(c + u_x)}{(N - Y)(c - u_x)}, \frac{u_x}{u_z}, \rho u_y, \rho \sqrt{c^2 - u_x^2}\right)$$

III. OPTICAL TRANSFORMATIONS AND THEIR INVARIANTS

The quantities that appear in the expression for the light vector

$$\sin \omega \left(t - \frac{l x + m y + n z}{c} \right)$$

are transformed by means of the set of equations:

$$l' = \frac{l - \frac{v}{c}}{1 - l \frac{v}{c}}.$$

$$\left. \begin{aligned} m' &= \frac{m}{\beta \left(1 - l \frac{v}{c}\right)} \\ n' &= \frac{n}{\beta \left(1 - l \frac{v}{c}\right)} \\ \omega' &= \beta \omega \left(1 - l \frac{v}{c}\right) \end{aligned} \right\} (1)$$

The differential form of this transformation is

$$\frac{-d l'}{1 - l'^2} = \frac{d m'}{l' m'} = \frac{d n'}{l' n'} = \frac{d w'}{-\omega' l'} = \frac{c \delta v}{c^2 - v^2} \quad (2)$$

with the usual initial conditions.

There are three independent expressions of these quantities that are invariant under the Lorentz transformation. They are

$$\frac{m}{n} \quad \frac{m}{\sqrt{1 - l^2}} \quad n \omega \quad (3)$$

The most general invariant involving these quantities only is an arbitrary function of the three invariants, to wit

$$F\left(\frac{m}{n}, \frac{m}{\sqrt{1 - l^2}}, n \omega\right) \quad (4)$$

If we take cognizance of the electro-magnetic origin of light through the equations

$$\left. \begin{aligned} X &= X_0 \sin \Phi & L &= L_0 \sin \Phi \\ Y &= Y_0 \sin \Phi & M &= M_0 \sin \Phi \\ Z &= Z_0 \sin \Phi & N &= N_0 \sin \Phi \\ \Phi &= \omega \left(t - \frac{l x + m y + n z}{c} \right) \end{aligned} \right\} (5)$$

then we are enabled to consider the transformation equations of

amplitude and energy of radiation. Their transformation equations have the form:

$$\left. \begin{aligned} A' &= \beta \left(1 - \frac{v}{c} l \right) A \\ E' &= \beta \left(1 - \frac{v}{c} l \right) E \end{aligned} \right\} (6)$$

Their corresponding differential form is:

$$\frac{d A'}{A' l'} = \frac{d E'}{E' l'} = \frac{c \delta v}{c^2 - v^2} \quad (7)$$

Let us consider at this point the question of finding the invariant expression that involves the energy and frequency of a radiation only.

It is the solution of the differential equation

$$\frac{d E}{E l} = \frac{d \omega}{\omega l}, \text{ namely } \frac{E}{\omega} \quad (8)$$

This is a significant result. A priori, the invariant might have been a sum or product or any other conceivable function of the quantities E and ω , but that it turned out to be the ratio $\frac{\text{Radiation Energy}}{\text{frequency}}$, the quantum, is very significant for the relativity theory from which it is derived. Einstein, in his original paper on the special theory of relativity, declared that it was remarkable that the energy and frequency of a light complex should both vary in the same manner as a result of changes in the state of motion of the observer.

It might be of some interest to gather together here the independent invariants of the most important quantities that present themselves in optical phenomena, such as the frequency of the radiation, the direction of the wave normal, the amplitude, the energy of the radiation. They are derivable from the equations

$$\frac{-d l}{l^2} = \frac{d m}{l m} = \frac{d n}{l n} = \frac{d \omega}{-\omega l} = \frac{d A}{-A l} = \frac{d E}{-E l}$$

as the solutions thereof. The invariants are

$$\left. \begin{array}{c} \frac{m}{n} \\ \frac{m}{\sqrt{1-t^2}} \\ n\omega \\ \frac{E}{\omega} \\ \frac{E}{A} \end{array} \right\} (9)$$

The general invariant function of these quantities is:

$$F\left(\frac{m}{n}, \frac{m}{\sqrt{1-t^2}}, n\omega, \frac{E}{\omega}, \frac{E}{A}\right) \quad (10)$$

In closing, I wish to express my indebtedness to my sister Ella for the inspiration she has been to me in this work.

GEOLOGY.—*On the geological age of Pleistocene vertebrates found at Vero and Melbourne, Florida.*¹ OLIVER P. HAY, Washington, D. C.

For a number of years I have been studying the vertebrates of the Pleistocene of North America and their relations to the deposits of this epoch. I have recognized, with others, that at the beginning of the Pleistocene there was a fauna extremely rich in genera and species, composed in part of animals native to the continent, in part of immigrants from Asia, and in part of invaders from South America. When white men arrived here the fauna had become relatively impoverished. Species, genera, and even orders of stately animals had disappeared; and the gaps had not been filled up either by development of new forms or by arrival from other lands. Furthermore, on the basis of the changing composition of the fauna, I have divided² the epoch into an Earlier and a Later Pleistocene.

Having reached and announced these conclusions I am impressed that some of my friends, paleontologists, geologists, and anthro-

¹ Received June 10.

² This JOURNAL 15: 126-133. 1925.

pologists, doubt the correctness of my views. Conscious of this dissent, I propose to discuss the subject once more.

There are certain animals which I believe characterize the Earlier Pleistocene and are absent from the later half of the epoch. These are the great ground-sloth *Megatherium*, the glyptodons, the camels, *Elephas imperator*, the mastodon *Anancus mirificus*, the great capybaras found in Florida and Texas, certain species of horses, the saber-tooth tigers of the genus *Smilodon*, and the gigantic tortoises of the genus *Testudo*. My reasons for believing that these remarkable mammals and reptiles were confined to the early half of the Pleistocene are as follows:

1. They and the deposits containing them have hitherto been regarded by most vertebrate paleontologists and geologists as appertaining to the early part of the epoch or to the Pliocene. Marsh and Cope originally referred what they called the *Equus* fauna to the upper Pliocene, until Gilbert demonstrated that it belonged in the Glacial epoch. Marsh went so far as to say that two species of *Bison* had been discovered in the Lower Pliocene. This assignment of the deposits containing the *Equus* fauna is not necessarily correct; but those who reject it are put under obligations to render some reasons for their procedure. Up to the present time, however, they have failed to do this. An exception to this statement is a paper issued recently by Kirk Bryan and J. W. Gidley.³ This concerns fossil horses, a camel, and *Elephas boreus*, discovered in Arizona. The argument in favor of a late Pleistocene age is based on the shallowness of the bone-bearing deposit.

2. Where from stratification of the deposits the geological age of the animals discussed can be determined they are found to belong to the Early Pleistocene. This demonstration is offered to us along Missouri River in South Dakota, Iowa, and Missouri. Here one or more species of camels, *Elephas imperator*, *Anancus mirificus*, and various species of horses occur between the first and the second drift sheets; that is in first interglacial, or Aftonian, deposits. On the other hand, neither in nor on any later deposit, glacial or interglacial, has *Elephas imperator*, or *Anancus mirificus*, or any camel, or certain species of *Equus*, or any species of *Smilodon* been discovered. Beyond the borders of the glaciated region, on the Great Plains, from South Dakota to the Gulf, camels are found associated with the others of the species mentioned, but never with the abundant and wide-spread existing bison.

³ Amer. Journ. Sci. 11: 477-488. 1926.

3. The composition of faunas, both of the land and of the sea, is subject to gradual change and has been so subject throughout all time. One species after another drops out of existence. These extinctions occur even when the environment seems favorable and undisturbed. How much then must the mortality have been increased during such an epoch as the Pleistocene, when the animals were subjected alternately to extremes of heat and cold, drought and humidity, abundance of food and scarcity of it. The answer to this is found in the copiousness of the early fauna, the relative poverty of the late.

In the stratum known as No. 2 at Vero and Melbourne occur *Glyptodon*, *Megatherium*, *Chlamytherium*, *Megalonyx*, *Mylodon*, *Equus*, *Tapirus*, *Camelops*, *Elephas imperator*, great dogs of the genus *Aenocyon*, the saber-tooth *Smilodon*, tiger-like species of cats, capabaras of bear-like size, tortoises larger than those from the Galapagos Islands, and many other species of less importance. In 1924 Dr. F. B. Loomis, of Amherst College, published⁴ a paper in which he gave it as his opinion that the animals belonged to the late Pleistocene. He offered no reasons for his conclusions. In 1926 Dr. J. W. Gidley, in an abstract of an address on the discoveries made at Melbourne, declared⁵ that the "general geologic conditions, as interpreted, suggest a relatively recent date, either late Pleistocene or even post-Pleistocene, for the extinction of the last survivor of the Pleistocene fauna in the south." The geologic conditions requiring this conclusion were not specified. Inasmuch as the animals occurring there were, without doubt, in North America at or soon after the beginning of the Pleistocene it follows that all of them were able to survive the vicissitudes of the Pleistocene and then, when the favorable Recent had arrived, they were by some strange visitation wiped out of existence. The tremendous difference between the early Pleistocene fauna and that of the Recent was then produced. In this connection it would be interesting to learn what important genera and species, in his opinion, became extinct during the early and middle portions of the Pleistocene; also how early Pleistocene deposits are to be distinguished from the latest.

4. As a method of determining the relative ages of deposits paleontologists and geologists have sought to use the percentages of living and extinct species. This practice is based on the conviction that faunas, as time passes, change somewhat gradually their elements.

⁴ Amer. Journ. Sci. ser 5, 8: 503-508

⁵ This JOURNAL 16: 310.

A cave in Pennsylvania furnished 28 species, of which 2 (7 per cent) appear to be extinct. Among the existing forms was the caribou. The geological time was probably near the end of the Wisconsin glacial stage. The percentage of extinct species at Vero and Melbourne may be taken as about 70. Which assemblage, the Pennsylvanian or the Floridan, is the older? What now is the value of the percentage method? Perhaps it is to be employed in an inverse sense, the higher the extinct percentage the younger the fauna?

5. Possibly something may be learned about Pleistocene history in North America from that of Europe. Events there ran about the same course as in America; at least, the geologists tell us so. Glacial stages and interglacial there appear to correspond in general with those in America. According to Haug,⁴ a French geologist, the Pleistocene was ushered in by an invasion of a new fauna which included elephants, oxen, and horses. The oldest formation is the Villafranchian, of Valle d'Arno, Italy. Haug gives a list of 22 characteristic species. Some of these do not occur in any later lists; others lived on to the middle of the Pleistocene; some to near its end; none now exist. Two genera of mastodons, *Mammot* and *Anancus*, became extinct in the first half of the epoch; a rhinoceros lived only a little beyond the end of the first half. The Cromer Forest bed in England belongs in the Early Pleistocene and furnishes a long list of species. According to Haug's list, 63 per cent of these are extinct, many of them not reaching the end of the first division. In the second division other elephants and rhinoceroses became the prominent elements of the fauna. These statements do not sound much like those which are being brought up to us from Melbourne.

I may be permitted to say, that if we leave the Recent out of Haug's classification of the Quaternary, the remainder is arranged in two divisions which agree quite closely with those of my own arrangement; and this was made before I had learned what Haug had done.

6. I have referred to the fact that *Elephas imperator*, *Anancus mirificus*, the camels, and the saber-tooth *Smilodon* are not found in or on any glacial deposit succeeding the Aftonian. How is this to be explained if those animals continued to exist up to near the present? We have been told that they were able to live near the glacial front and there to mingle with musk-oxen and reindeer from the Arctic. As the Kansan ice sheet receded the megalonyx, the mylodon, the American mastodon, the Columbian elephant, *Elephas boreus*, the musk-oxen, and a host of other species followed the glacier

⁴ HAUG, E. *Traité de Géologie*, pp. 1760. 1921.

and occupied their ancient pastures. Why did not the imperial elephant, the mirific mastodon, and the camels do likewise? My explanation is that they no longer existed. My critics may adopt a theory quite opposite their former one and assert that these species had been driven southward where the climate was milder; that they remained there and made their last stand around the Gulf and in Mexico. The geological history of the other elephants, of the American mastodon, of a few species of horses, of the bisons, the peccaries, the wolves, and the giant beaver, contradicts the idea that even the succession of at least four glacial stages and three interglacial changed the habits of the Pleistocene animals. Reindeer and musk-oxen might have remained, if willing, in New England to enjoy the warmer climate, but as fast as the way was cleared for them they betook themselves to the frigid north. *Elephas imperator* has been found as far north as Helena, Montana, and the northwestern corner of South Dakota. I regard these finds as belonging to the Earlier Pleistocene. If of a later time, the species had not been driven south; also, it had not ventured to return to Iowa. Farther south, at Afton, Oklahoma, within less than 300 miles of the glaciated region have been collected 2 species of camels, apparently 5 species of horses, *Elephas columbi*, *E. imperator*, and the common mastodon. All were found not far from the surface, in a spring, associated with numerous flint implements. At whatever Pleistocene stage these animals were buried, the mastodon, the Columbian elephant, apparently one kind of horse, the giant beaver, and others were able to spread over the grassy plains of Missouri, Iowa and Illinois; but these plains had no attractions for the imperial elephant and the camels.

The reluctance to admit the early Pleistocene age of the animals of stratum No. 2 at Vero and Melbourne is due to at least two beliefs. One of these is that the terraces along the coast are of marine origin and have been built up at intervals during the Pleistocene. If this theory is correct the lowest terrace naturally must be regarded as comparatively young. I may be excused for referring to a paper¹ in which I try to show the improbability of a marine origin, because of the utter lack of marine fossils in them, except in the lowest part of the lowest one. On the Pacific Coast there are high and low marine terraces, but they betray their origin by the inclusion of sea-shells. At many places in Europe are found similar Pleistocene terraces, but they are known to be of marine origin from the fossils they contain. It is wholly improbable that molluscan shells buried

¹ This JOURNAL 14: 255-264.

in deposits laid down, as on our coast, along such a vast extent of shore, composed of materials of every sort, should, when the deposits are lifted above the sea, be dissolved out without leaving a remnant of shell or a hole where they had been buried. Another factor influencing opinions as to the age of the deposits and fossils at Vero and Melbourne is the presence of men's bones and artifacts. I think I am not wrong in saying that this has been the determining element in this reference of stratum No. 2 to the late Pleistocene or to the post-Pleistocene. It is the olive branch offered to the anthropologists. They may be reconciled to the companionship of man with camels and glyptodons, in case it was only a few thousands of years ago. I do not believe that the late arrival of man in America is a fact so well demonstrated that geology and paleontology must yield unquestioning assent. In case Doctor Gidley has proved that his human remains were originally buried where found, he has demonstrated a much earlier coming of man than he supposes.

BOTANY.—*A new genus of palms based on Kentia forsteriana.*¹

O. F. Cook, Bureau of Plant Industry, U. S. Department of Agriculture.

Lord Howe Island, in the south Pacific, between Australia and New Zealand, has four endemic palms, including two species of commercial importance. For many years the seeds have been collected in large quantities and shipped to Europe and America for raising the seedlings in greenhouses. The species known as *Kentia forsteriana*, with gracefully drooping deep-green leaves, is the most familiar palm in household cultivation.

All of the Lord Howe palms were described originally as species of *Kentia*,² but have been transferred to other genera. The two com-

¹ Received July 3, 1928.

² VON MUELLER, *Fragmenta Phytographia Australis* 7: 99 1870; 8: 234 1874

The botanical history of the palms of Lord Howe Island can be traced through the writings of Helmsley, Maiden and other authors. The most recent and complete account, with photographs of the palms in their native habitats is by W. R. B. Oliver, "The Vegetation and Flora of Lord Howe Island," *Transactions and Proceedings of the New Zealand Institute* for 1916, pages 94 to 161, issued December 20, 1917. A list of publications is included, but does not contain citations to the original descriptions of the palms, in 1870 and 1874, nor to the first account of the discovery of the palms by C. Moore, Director of the Sydney Botanic Gardens, which was published in *The Gardeners' Chronicle* for September 11, 1869, six months in advance of the botanical descriptions. Moore recognized the four kinds of palms on Lord Howe Island as distinct and new, and supplied the material used by von Mueller in naming the species. Von Mueller states that the name *forsteriana* was applied to the Thatch Palm at Moore's request. The paper sent to *The Gardeners' Chronicle* was dated at the Sydney Botanic Gardens June 16, 1869, and states that three days had been spent on Lord Howe Island.

mercial species have been assigned to *Howea*, as *Howea belmoreana* and *Howea forsteriana*. The name *Kentia* is likely to continue in commercial use, although the commercial *Kentias* are not closely related to *Kentia procera*, the original species described by Blume in 1836, from New Guinea. Both of the commercial species are growing and fruiting in the open air in California, where comparisons of the adult characters have been made.

The usual household specimens of these palms show only the juvenile characters. Larger size is attained in greenhouses, but the fruiting state apparently is not reached. The propagation of the commercial *Kentias* has depended entirely upon the imported seed. Recently it is reported that the supplies from Lord Howe Island are endangered by a plague of rats. Though only a few of the palms in California have begun to fruit, they appear well adapted to the coast districts and produce viable seeds.

Baron von Mueller published the original descriptions of the Lord Howe palms in 1870, and gave a correct account of the simple spadix and spathe of *Kentia belmoreana*, showing that the specimen was complete. The inflorescence of *K. forsteriana* was stated to be incomplete, and evidently consisted of a part of one of the branches. Further data were supplied in 1874 in what appeared to be an amended description of *Kentia belmoreana*, but with a compound inflorescence and floral characters different from those of the description of 1870.

The discrepancies may be explained by considering that the data of 1874 relate to *K. forsteriana*, and presumably were intended to supplement the incomplete and informal description of that species in 1870. The mention of *K. belmoreana* instead of *K. forsteriana* may have occurred as a mere accident in writing the name, or possibly through a mistake in labeling specimens. It would not be admitted that the name *K. belmoreana* could be transferred to a different palm by amending the description, even if that had been the author's intention.

The effect of ascribing a compound inflorescence to *K. belmoreana* was to reverse the use of the names, and this may explain the confusion in botanical and horticultural literature. The descriptions and figures of the two species published in *Linnaea* by Wendland and Drude in 1875 also have the names interchanged. The longer fruits and seeds are associated with *K. belmoreana*, whereas they belong to *K. forsteriana*. A leaf-section with the midrib prominent above but not prominent below is assigned to *K. forsteriana*, while in reality such a midrib is characteristic of *K. belmoreana*.

Several writers have doubted or denied that the species were dis-

tinct, perhaps from seeing palms of the same species under both names. Much that has been written of *K. belmoreana* applies rather to the true *K. forsteriana*. The latter is preferred for ornamental use, as being a hardier and a more beautiful palm, especially in the younger stages of growth. The strongly curved rachis and erect pinnae of *K. belmoreana* also afford striking contrasts with the straight rachis and horizontal pinnae of *K. forsteriana*.

Male flowers with about 30 stamens were described by von Mueller in the original account of *Kentia belmoreana* in 1870, while flowers with 50 to 70 stamens were reported in 1874 in connection with the description of the compound inflorescence published under *K. belmoreana*, but apparently relating to *K. forsteriana*, as already explained. Also it appears that the flowers of the compound inflorescence of 1874 had longer anthers than those of the simple inflorescence of 1870.

The Index Kewensis does not cite the original description of *Kentia forsteriana* in 1870, but refers to the name as it appeared in a checklist of palms published in 1878, from which it might be inferred that the species had not been established before. The description of 1870 leaves no doubt of the author's intention to associate the name *K. belmoreana* with the "Curly Palm" of Lord Howe Island, and the name *K. forsteriana* with the "Thatch Palm" or "Flat-leaved Palm," as the species were recognized by the settlers. The local names were significant, because the straight leaves of *K. forsteriana* would lie flat on a roof, while the strongly recurved leaves of *K. belmoreana* would not serve for thatch. The species to which the name *K. forsteriana* belongs, with the flat leaves, compound inflorescences, and other distinguishing features, now appears to be entitled to rank as a separate genus, which is here described. The other species, *K. belmoreana*, with the simple inflorescences and curved leaves, is considered to be the type of *Howea*.

A separation of the two species *K. belmoreana* and *K. forsteriana* from *Kentia* was suggested by von Mueller in 1870 on the ground of the simple inflorescence, which at first was supposed to be a character of both species. The suggestion was adopted by Wendland and Drude in 1875 in establishing a new genus, *Griesebachia*, but that name was preoccupied. Beccari in 1877 replaced *Griesebachia* with *Howea*, which later authors have modified into *Howea*. While no species was designated as the generic type, *K. belmoreana* was the first and better-known species assigned to *Griesebachia* and *Howea*, and the only one with the simple inflorescence given as a generic character.

Denea, new genus

Closely related to *Howea*, but the trunk tall with uneven, oblique leaf-scars; the leaf with a straight rachis and flat, horizontal or drooping pinnae; the inflorescence compound, of several subequal crassate divisions, each inclosed in a separate complete spathe; the flowers and fruits inserted in deep alveoles with the subtending bracts forming prominent indurated rims; the seeds oblong, with a small round operculum; and the seedlings with simple bilobed leaves, not divided into segments, usually with four simple leaves before the appearance of a compound leaf with separate segments.

In *Howea* the trunk is short, with close, horizontal leaf-scars; the leaf has a strongly decurved rachis and erect pinnae, strongly arched or channeled underneath; the inflorescence is simple, with smaller alveoles and thin, subscariosus rims; the seeds are obovoid with a large oval operculum embracing the hilum; and the seedling leaves are compound, the first two leaves usually with four separate segments.

Undoubtedly the genera are rather closely related and they are specialized on similar lines for maintaining their existence in extra-tropical oceanic climates. But the differences of habit and structure are definite and of a nature to suggest long-standing evolutionary divergence.

The trunk in *Denea* is taller than in *Howea*, with longer internodes, separated by oblique leaf-scars, the leaf-scars of *Howea* being transverse and close together. Under slathouse conditions the internodes attain a length of 12 cm., but are much shorter in the open. The internodes have a green epidermis that remains alive for several years. The trunks are reported as attaining 60 feet and upward in Lord Howe Island, or about twice as tall as *Howea*.

The leaf-sheaths of *Denea* are resolved along the margins into an abundant network of pale, light-brown fibers, while in *Howea* there is only an open fringe of dark fibers in the upper part of the sheath.

In *Denea* the leaf has a long petiole, with a straight rachis and horizontal or drooping, flat, open-spaced pinnae, while *Howea* has a short petiole, a strongly recurved rachis, and close-set stiffly erect pinnae, deeply channeled underneath and arched in cross-section. The midribs of the pinnae of *Denea* are prominent below as well as above, while those of *Howea* are prominent on the upper side but not underneath. Thus the pinnae of *Howea* have several specialized characters that make it possible for them to stand upright or in ascending positions. The curved rachis and crowded erect pinnae are chiefly responsible for the very peculiar habit of the palm.

The inflorescences of *Denea* are interfoliar, developing from the axils of younger leaves than in *Howea*, but are so persistent as to outlast the leaves, and then appear infrafoliar. Eventually the mature branches, weighted with the close-set fruits, become pendent, though the basal joint of the inflorescence remains upright and appressed to the trunk. The inflorescences of *Howea* appear among the older leaves and at maturity become definitely infrafoliar, with the basal joint greatly swollen and divergent from the trunk.

The inflorescence of *Denea* is branched, while that of *Howea* is simple. The divisions vary in number from 3 to 8, with 5 as the usual

number, and are nearly equal, with no indication that one branch represents a central axis on which the others are inserted. Each branch of *Denea* corresponds to the simple inflorescence of *Howea*, but the several branches have a broad basal joint, 5 to 6 cm. long, in common, as though several simple inflorescences had united their basal joints. Thus the very peculiar inflorescence of *Denea* consisting of several branches, each inclosed in a separate spathe corresponding to the complete spathe of *Howea*, suggests derivation from a palm like *Howea*, with simple inflorescences. If derived from a branching inflorescence of the usual type it would be expected that a complete spathe would include all of the branches, as with the many palms that have complete spathes.

Occasionally a primary branch of the inflorescence is forked above the insertion of the spathe, which then includes the two subdivisions together. As a result of the branching of the inflorescence and of the narrower and more closely crowded fruits, *Denea* is several times as prolific as *Howea*. On one of the branches of a *Denea* inflorescence 340 fruits were counted. The number of alveoles on a branch is about 400.

The spathes of *Denea* are fibrous and persistent, while those of *Howea* are of thinner and more papery texture and deciduous before flowering. The young spathes of *Denea* are whitish, becoming light brown, and apparently do not contain chlorophyll at any stage.

The alveoles of *Denea* are subtended by thickened, indurated, persistent rims, transverse or broadly emarginate in the middle and distinctly notched at the angles, while in *Howea* the rims are thin and often scarious with no distinct notches at the angles. Apparently the rims of *Denea* were developed from the bracts, like those that appear at the base of the spike, below the fertile alveoles. In *Howea* the corresponding bracts of the sterile alveoles are obsolete, or are completely fused to form the very thin transverse rims. It seems that in *Denea* the bracts subtending the alveoles were retained and developed into the prominent rims, while in *Howea* the bracts were suppressed. In both genera there is a large coriaceous bract inside the alveole, apparently subtending one of the male flowers, while the other flowers are subtended by smaller bracts.

The sepals of *Denea* are imbricate and the petals valvate in the male flowers, but in the female flowers the petals also are imbricate and of heavy, indurated texture with densely fringed margins. Surrounding the base of the fruit are three triangular staminodia, somewhat larger in *Denea* than in *Howea*.

The fruits of *Denea* are longer and more gradually pointed at the ends than in *Howea*, with the stigmatic area more prominent. The exocarp is thicker than in *Howea*, especially at the ends, while the endocarp is thinner, smoother and more transparent, so that the branches of the raphe are perceptible through the endocarp. A regular columnar structure is shown when the endocarp is broken, as in *Pseudophoenix*, *Manicaria* and *Phytelephas*.

The seed in *Denea* is longer and narrower than in *Howea*, and often flattened by the mutual pressure of the fruits. The operculum is small and circular in *Denea*, separate from the hilum and scarcely broader. In *Howea* the seed is ovoid and the operculum forms a prominent oval area distinctly broader than the hilum, and embracing it on the sides. The hilum in both genera is rather prominent and with a few coarse pits, much as in *Pseudophoenix* and *Phytelephas*.

The seedlings of *Denea* have simple, bilobed leaves, and usually there are four such leaves before any separation of segments takes place. Usually the fifth leaf is 4-parted. In *Howea* the first two leaves usually have four separate segments, sometimes 6 or 7, while the third and fourth leaves usually have 8 to 10 segments. Sometimes the first leaf and in rare cases the second leaf in *Howea* may be simple, but never the third or fourth leaves, which generally are simple in *Denea*.

The name *Denea* is derived from the Greek adjective *denaios*, meaning long-lived or enduring, in allusion to the remarkably persistent inflorescences and fruits. Instead of reaching a definite period of maturity the fruit-bearing inflorescences may complete their development and remain in place for several years, with the tissues alive and the fruits firmly attached in the deep alveoles, the exocarp green, and the embryo dormant. The seeds also have unusual vitality, if protected from drying. Some of the seeds may germinate in a few months after planting, while others may lie in the ground for three or four years before sprouting. Thus it appears that a decade may elapse between the flower and the germination of the seed.

Specimens of *Denea forsteriana* (F. Muell.) Cook, showing the inflorescences, fruits and seeds, with photographs of the palms growing in the vicinity of San Diego California and details of the structural characters in natural size have been deposited in the U. S. National Herbarium, as record material.

RADIOTELEGRAPHY—*Long distance radio receiving measurements and atmospheric disturbances at the Bureau of Standards in 1925*¹ L W AUSTIN Laboratory for Special Radio Transmission Research²

The following is a resume of the measurements made by the Bureau of Standards on long wave long distance signal intensities at atmospheric disturbances during 1925 with the addition of some comparisons of the field intensities and disturbances from 1922 to the present time

The method of measurement is the same as has been used in former years except in the case of reception through disturbances considerably stronger than the signals which as is well known, tend to reduce the apparent signal strength The necessary correction under these circumstances is now determined for each individual case by observing an artificial signal of the same apparent strength as the signal being measured both with and without the disturbances In this determination the artificial signal is introduced directly into the secondary of the receiver (not through the antenna) from a loosely coupled radio frequency generator

In the first case the antenna is coupled normally so that the disturbances are received with the artificial signal then the antenna is replaced by an artificial antenna with exactly the same constants and coupling to the secondary so that the beat note remains unchanged in shifting from one to the other A simpler method of correction described in the report for 1924 did not prove entirely satisfactory under all circumstances on account of variations in the character of the disturbances

In April, 1925, Dr Dellinger, Chairman of the Committee on Measurements and Standards of the American Section of the U R S I, requested the Radio Corporation of America and the Bell Laboratories to bring long-wave field intensity measuring apparatus to Washington for comparison with the apparatus used at the Bureau of Standards The methods used by the two companies were alike in employing a radio-frequency comparison in which the signal being measured is matched by an artificial signal of adjustable intensity, produced by a local radio-frequency generator

¹ Published by permission of the Director of the Bureau of Standards of the U S Department of Commerce

² Conducted jointly by the Bureau of Standards and the American Section of the International Union of Scientific Radio Telegraphy

In the Bell Laboratories system³ the current for the local signal is first measured and then attenuated in a resistance network and introduced into the coil antenna at its middle point through a 1-ohm

TABLE 1.—APPROXIMATE TRANSMISSION DATA

	FRE- QUENCY f	WAVE LENGTH λ	ANTENNA CURRENT I	EFFECTIVE HEIGHT h	DISTANCE d
	kc.	m	mwp.	m	km
LY* Bordeaux	15.9	18900	540	180	6160
FU Ste. Assise, Paris	15.0	20000	475	180	6200
FT Ste. Assise, Paris	20.8	14400	380	180	6200
AGW* Nauen, Berlin	16.5	18100	460	170	6650
AGS* Nauen, Berlin	23.4	12800	400	130	6650
IDG Pisa	14.2	21000	—	—	7300
KET* Bolinas, San Francisco	22.9	13100	670	51	3920
LPZ Monte Grande, Buenos Aires	23.6	12700	600	150	8300
GBL Leafield, Oxford	24.4	12300	260	75	5900
NAU Cayey, Porto Rico	33.8	8870	150	120	2400

* Daily antenna current reported. Other antenna currents more or less uncertain.

TABLE 2.—AVERAGE SIGNAL INTENSITY AND ATMOSPHERIC DISTURBANCES FOR LAFAYETTE (LY), STE ASSISE (FU), NAUEN (AGW), AND PISA (IDG) IN MICROVOLTS PER METER

1925	A. M.					P. M.				
	LY	FU	AGW	IDG	Dist.	LY	FU	AGW	IDG	Dist.
January	111.3	31.0	—	45.7	33.3	108.6	56.1	—	96.7	40.0
February	105.9	38.4	44.0	24.0	57.3	119.4	52.8	56.2	68.8	94.9
March	118.0	51.3	51.8	43.3	70.4	108.7	38.2	52.8	50.5	146.9
April	117.8	57.0	42.8	59.7	83.4	96.7	31.0	39.3	18.0	237.1
May	120.6	61.6	50.4	62.4	54.8	99.2	36.5	33.3	33.6	158.4
June	106.9	50.7	54.2	52.9	60.1	84.5	24.2	20.9	19.7	239.4
July	119.5	58.4	53.1	53.9	57.1	94.0	42.5	38.1	54.0	242.2
August	137.5	84.6	74.4	63.1	42.7	73.0	45.2	40.4	50.1	208.9
September	140.1	83.6	78.6	—	52.5	102.0	56.7	49.2	—	107.6
October	137.7	63.0	60.0	—	45.9	171.0	79.8	69.7	—	73.1
November	117.1	58.9	56.0	—	41.4	206.0	87.4	80.8	—	59.5
December	124.1	54.0	52.9	—	49.6	267.1	114.1	88.3	—	55.9
Average	121.2	57.4	56.6	50.6	54.0	132.5	55.3	51.7	48.9	138.6

resistance; while the Radio Corporation⁴ regulates the intensity of the local signal and introduces it by means of a calibrated mutual inductance. The Radio Corporation method is of especial interest

³ Proc. I. R. E., 11: 115. 1923.

⁴ Proc. I. R. E., 11: 661. 1923.

since it is identical in principle with the methods commonly used for radio field intensity measurement in England, France and Germany. At the Bureau of Standards, long-wave field intensities are measured

TABLE 3—AVERAGE SIGNAL INTENSITY AND ATMOSPHERIC DISTURBANCES FOR STE ASSISE (FT), BOLINAS (KET), NAUEN (AGS), MONTE GRANDE (LPZ) AND LEAFIELD (GBL) IN MICROVOLTS PER METER

1925	A.M.						P.M.				
	UFT	KET	AGS	LPZ	GBL	Dist	UFT	KET	AGS	LPZ	Dist.
January	31 9	54 2	20 0	54 2	—	26 0	44 8	52 4	34 7	—	35 6
February	35 6	45 4	24 6	57 1	—	44 5	35 8	56 7	35 1	—	76 2
March	36 9	40 4	27 1	55 7	—	56 8	29 4	48 0	24 4	26 8	119 1
April	44 8	59 2	24 7	41 8	—	67 3	28 0	45 9	18 8	19 7	194 2
May	46 1	56 4	32 9	49 0	15 5	46 2	27 5	41 9	17 4	23 5	145 0
June	46 8	53 7	37 5	40 2	17 9	51 3	18 5	23 4	16 0	—	217 4
July	45 4	58 0	35 8	39 9	19 6	42 5	28 6	36 6	21 4	—	213 0
August	53 1	62 1	46 5	45 6	23 2	32 7	28 0	43 0	22 9	—	185 5
September	50 6	70 6	48 6	45 9	21 7	38 7	33 3	46 5	24 7	—	88 2
October	47 5	66 7	35 8	44 9	21 5	38 7	46 2	60 5	38 5	—	58 5
November	41 6	63 0	28 1	50 7	17 1	34 0	56 7	65 0	38 5	—	52 2
December	48 5	70 4	24 1	60 3	23 6	41 6	71 3	78 0	40 2	—	48 5
Average	44 1	59 1	32 1	48 7	20 0	43 4	37 3	50 5	28 4	—	119 4

TABLE 4—AVERAGE SIGNAL INTENSITY AND ATMOSPHERIC DISTURBANCES FOR EL CAVEY (NAU) IN MICROVOLTS PER METER

1925	A.M.		P.M.	
	NAU	Dist	NAU	Dist
January	71 1	9 5	59 3	8 5
February	57 2	15 3	72 2	22 6
March	58 2	22 0	44 2	44 0
April	55 1	25 6	42 4	77 9
May	80 3	28 6	52 4	77 4
June	83 3	25 7	49 1	129 1
July	77 6	28 1	52 1	104.5
August	80 2	15 0	65 0	91.8
September	72 2	22 1	63 9	46 1
October	81 5	26 1	62 6	35 0
November	73 0	16 5	60 7	23 0
December	77 0	21.2	89 7	22 5
Average	72 2	21.3	59 4	56.8

with the telephone comparator¹ in which a known audio-frequency signal is matched against the signal as heard in the telephones of

¹ Proc. I. R. E., 12: 521. 1924.

the receiving set. Special calibrations of the apparatus are made from time to time either by means of a local generator or from signals of known intensity. The agreement between the three systems of measurement was very satisfactory, when the disturbances were not too heavy; the differences being generally less than 20 per cent on distant signals, with still better agreement on the nearer stations.

The tables and curves^{*} giving the results of the year's work at the Bureau of Standards are self-explanatory. In addition to the data for 1925, the curves show also some comparisons of the field intensities of various stations and the strength of the atmospheric disturbances

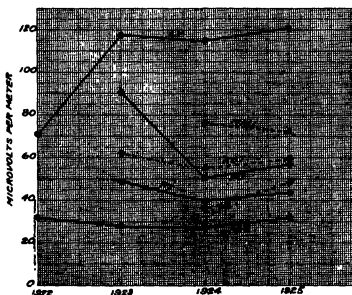


Fig. 1.—Annual average signal, 10 A.M., 1922, 1923, 1924, and 1925

in former years due to difficulty in making accurate measurements of the actual field strength of atmospheric disturbances the results shown in the curves of atmospheric disturbances are expressed in equivalent microvolts per meter.

The seasonal variations of the continental European stations as observed in Washington now seem to be fairly clear. The 10 A.M. observations give all daylight path conditions, though during the

^{*} The measurements are taken when possible on moderate speed transmission, as speeds above fifty words per minute are found to reduce the received field intensity in a marked degree.

It is also to be noted that the two Ste. Assise stations formerly UFT and UFU are now FT and FU, while the old Nauen POZ is now AGS.

shortest days of winter the Nauen observations, with 6 hours difference of time, have to be taken somewhat before 10 A.M. The winter A.M. signals of the northern European stations are weak in America, owing either to the approach of sunset in Europe, or to the proximity of the arctic darkness along the signal path as suggested by Espenschied, Anderson and Bailey⁷ or possibly to a combination

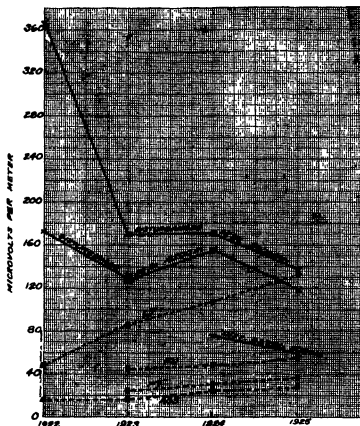


Fig. 2.—Annual average atmospheric disturbances and signal, 3 P.M., 1922, 1923, 1924, and 1925.

of these causes. The 10 A.M. signals become in general stronger through the spring and summer and reach a distinct maximum about September, after which they fall to their low winter values. The course of the 3 P.M. signals which are transmitted at about 8 P.M. in western Europe or 9 P.M. in central Europe and hence have a path of partial darkness during most of the year is the reverse of that of

⁷ Proc. I. R. E., 14: 7. 1926.

the 10 A.M. all daylight signals. The maximum occurs in mid-winter with a minimum in summer. The 10 A.M. and 3 P.M. curves cross each other as a rule in March and October. The 3 P.M. winter maxima are particularly strong in the case of the longer wave stations, Bordeaux LY, Ste. Assise FU, and Nauen AGW.

This strengthening of the 3 P.M. European signals in winter, with darkness extending over part of the signal path, does not seem to

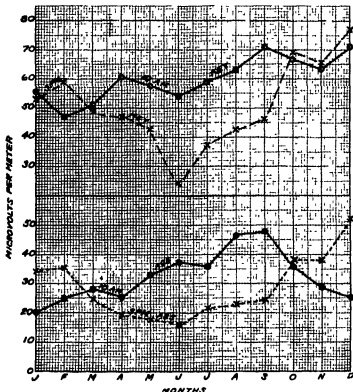


Fig. 3.—Nauen (AGS) and Bolinas (KET) average signal, 10 A.M. and 3 P.M., 1925

agree with the observations of Espenschied, Anderson and Bailey on signals between England and America, who found low intensities for partly dark signal path. We have, however, no observations on European stations of a wave length below 12,000 m., while the most pronounced drop in intensity as noted by the Bell observers was at much shorter wave lengths.

The west-east transcontinental signals from KET, Bolinas, California (three hours time difference), which have an all daylight path during both observation periods show practical equality of the 10 A.M.

and 3 P.M. signals in winter, while in summer the afternoon signals fall well below those of the morning. The same can also be said in regard to the signals of NAU, Cayey, Porto Rico (approximately south-north transmission) at a distance of 2500 km. In the case of Monte Grande, Argentina, LPZ (south-north transmission) at a distance of 8300 km. and with a little more than an hour's difference in time, there has been until recently no regular afternoon transmission. The morning signals from this station have shown no great seasonal variations, which was to be expected since the signal path is

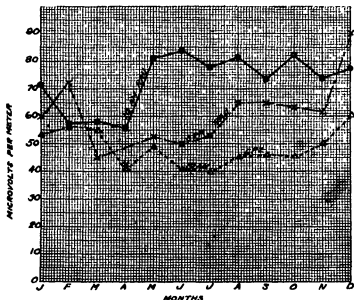


Fig 4—El Cayey (NAU) and Monte Grande (LPZ) average signal, 10 A.M. and 3 P.M., 1925.

divided nearly equally between the northern and southern hemispheres. From the data available it seems that the afternoon signals are much weaker than those of the morning in winter and spring, and it is probable that this difference persists throughout the year. The cause of this weakening of signals in the afternoon, which is observed on practically all stations in summer, even when there is comparatively little difference of time and no question of sunset or darkness effect, is not clear. It may be connected with absorption due to ionization in the lower atmosphere along the signal path, produced by the same conditions which produce atmospheric disturbances in the afternoon along the same path.⁵

⁵ Several years ago Navy operators in Panama reported weak signals from Washington whenever bad disturbance days occurred in the eastern United States.

In Fig. 8, the monthly averages of the 3 P.M. signals from Bordeaux (LY) received in Washington and those of the corresponding signals taken at Meudon near Paris ($d = 510$ km.) are shown. The remarkable agreement in seasonal variation at these two receiving stations, which has not been observed in other signals taken at moderate and long distances, and which did not occur before LY's change of wave length from 23,400 m. to 18,900 m., indicates that the variations observed in Bordeaux signals are due to causes in the neighborhood of the transmitting station and not in the general trans-

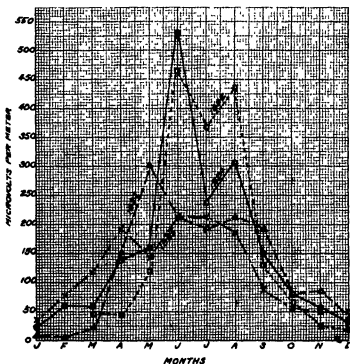


Fig. 5.—Average atmospheric disturbances, 3 P.M., for 1922, 1923, 1924, and 1925 $f = 24$ kc. (12500 m.).

mission paths. In addition to the agreement in seasonal variations at Washington and Meudon, it is to be noticed that there has been a gradual increase in Bordeaux's intensity at both receiving stations which is out of proportion to the average increase in antenna current.

During the year a slight modification has been made in the constants of the exponential term $e^{-\alpha}$ of the Austin-Cohen transmission formula, which has resulted in a great improvement between the observed and calculated values at the greater distances without impairing the

accuracy of the formula at moderate distances. The value of the exponent, u , expressed in km and wave lengths, is now

$$\frac{1.4 \times 10^{-3} d}{\lambda^{0.6}} \text{ instead of } \frac{1.5 \times 10^{-3} d}{\lambda^{0.5}}$$

where d is the distance and λ the wave length, or expressed in km. and kc., $u = 4.57 \times 10^{-3} d \times f^{0.6}$. This change approximately doubles

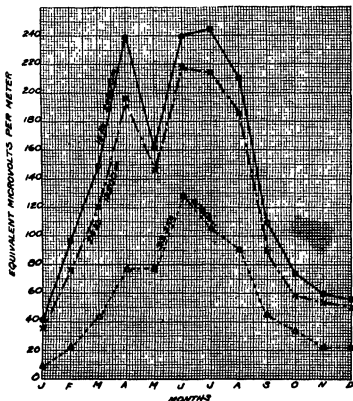


Fig 6.—Average atmospheric disturbances 3 p.m., for 1925. $f = 15$ kc. (20000 m), 24 kc (12500 m), and 33 kc (9000 m).

the calculated values at 6000 km. and increases them about four times at 12,000 km.

An examination is now being made of the transmission data already collected for the purpose of finding possible connections with other natural phenomena. Special study has been given to possible meteorological relations. It appears that for long distance long-wave transmission, for example between Europe and America, the connection between signal strength and American weather is not

close. This is not remarkable since the meteorological data in America can apply to only a small portion of the signal path. A much more distinct relationship exists in transmission over a few

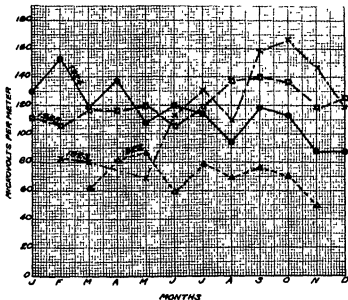


Fig. 7.—Lafayette (LY) average signal, 10 A M, 1922, 1923, 1924, and 1925

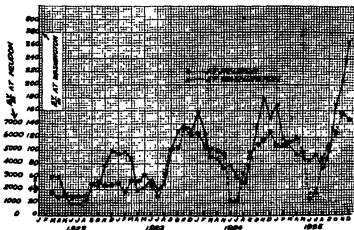


Fig. 8.—Lafayette (LY) average signal at Meudon and Washington, 3 P M, 1922, 1923, 1924, and 1925.

hundred km. because in these cases the weather is comparatively uniform over the whole path. This will be discussed in a later report.

Comparisons have also been made between European signal in-

tensity in Washington and the occurrence of sunspots* and magnetic storms. Thus far no certain relationship has been observed between sunspots and abnormal signals, but there appears to be in many cases an undoubted effect of the more severe magnetic storms upon transmission.¹⁰

During the year directional measurements on the atmospheric disturbances were made at frequencies of 21.4 and 15 kc. (14,000 and 20,000 m.) at the U. S. Naval radio receiving stations at Colon and Balboa at the two ends of the Panama Canal.

The data obtained seem to warrant the following conclusions:

1. During the dry season, probably from January 15 to April 1, the atmospheric disturbances both at Balboa and Colon come almost entirely from the South American continent, from the direction of the high Andes in northern Colombia, i.e., from the southeast.

2. When the dry season comes to an end and local storms begin to appear, the local disturbances from the low mountains of the isthmus begin to be prominent. This shifts the prevailing direction at Balboa at times from the southeast to the north, but has little effect on the direction at Colon since the mountains containing the local centers of disturbance here lie to the south and east, or roughly in the direction of the disturbance sources in Colombia.

3. In midsummer, while there is probably much disturbance from Central America and Mexico, the local disturbances from the isthmus mask this to such an extent that the prevailing direction at Colon continues roughly southeast, while at Balboa, the distant and local disturbances unite to give a northerly or northwesterly direction.

4. The observations further indicate that from northern sending stations, Balboa and Colon should give nearly equally good unidirectional reception in the dry season, but during the rest of the year, where the disturbance conditions are more troublesome, Colon should have considerable advantage over Balboa.

Observations in Washington show that in winter the prevailing afternoon disturbances come roughly from the southeast, that is, from the direction of eastern South America or perhaps in part from Africa. In summer the direction is southwesterly, apparently from Mexico or the southwestern United States. This is in accord with the idea that disturbances generally originate over land and are most intense in the afternoon and evening in the regions where the sun passes very nearly overhead.

* For a complete study of the possible relationship between radio phenomena and solar activity observations covering at least one complete sunspot cycle will be necessary.

¹⁰ ESPENSCHIED, ANDERSON and BAILEY, *loc. cit.*, have noticed in their measurement of signals between England and America that magnetic storms produce a marked decrease in night signals and a slight increase in day signals.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 16

SEPTEMBER 19, 1926

No. 15

PETROLOGY.—*Granites of Central Spain.*¹ HENRY S. WASHINGTON,
Geophysical Laboratory, Carnegie Institution of Washington.

According to Suess,² following Macpherson³ and Calderon,⁴ the Iberian Peninsula consists essentially of three main tectonic features: the Iberian Meseta or central plateau, bounded on the south by the folded Betic Cordillera, and on the north by the chain of the Pyrenees, which extends westward into the Cantabrian Cordillera. The central meseta consists of pre-Cambrian and Paleozoic rocks, into which granites and other igneous rocks were intruded in Carboniferous time.⁵ The meseta is divided from east to west by the granitic Sierra de Guadarrama, north of Madrid, with its westerly continuation, the Sierra de Gredos, and Mesozoic and later rocks overlie the granites and the earlier sedimentary ones.

In many papers, mostly short, Calderon, Navarro and other Spanish petrographers have described the igneous rocks of the central meseta, and have shown that the granites are accompanied by quartz porphyry, diorite, diabase, teschenite, basalt, and some rarer types, especially a little nephelite basalt and limburgite. But, with one exception,⁶ no analyses of any of these rocks seem to have been published. Some years ago Professor L. F. Navarro was good enough to send me a set of specimens of representative rocks from the Iberian Meseta, a kindness which

¹ Received July 13, 1926

² SUSS, *The Face of the Earth*, (English translation) 2: 122. 1906.

³ MACPHERSON, *Anal. Soc. Espan. Hist. Nat.* 30: 123. 1901

⁴ CALDERON, *Ibid.*, 14: 131. 1885.

⁵ There seems to be considerable diversity of opinion as to the details of the structure of the peninsula and the age of the intrusion of the granites. Cf. Dupuy de Lome and de Novo, *Guías Geol. Líneas Férreas*, Cong. Geol. Int., XIV, Madrid-Irun, p. 24, Madrid-Sevilla, p. 8; 1926. I have been unable to consult Donville's "Spain," in the *Handbuche der regionalen Geologie* (1910).

⁶ NAVARRO, *Trab. Mus. Nac. Cien. Nat.*, Serie Geol. 12: 73. 1915.

is deeply appreciated. Chemical analyses were made of several specimens of granite, including one collected by me at Villalba, near the Escorial, in 1905. The present note embodies a study of these specimens.

All the four granites, analyses of which are given in Table 1, are much alike megascopically. They are simple biotite granite, very light in color, composed of white feldspar and quartz, with small flakes

TABLE 1—GRANITES OF SPAIN

	(1)	(2)	(3)	(4)
SiO ₂	69 83	69 86	68 56	70 38
Al ₂ O ₃	15 07	15 32	14 66	14 71
Fe ₂ O ₃	0 17	0 05	0 63	0 29
FeO	2 72	2 49	3 02	2 35
MgO	0 60	0 64	1 07	1 33
CaO	2 48	2 45	2 08	2 62
Na ₂ O	3 38	3 68	3 36	2 90
K ₂ O	3 90	3 79	5 27	4 58
H ₂ O+	0 50	0 22	0 32	0 15
H ₂ O-	0 14	0 12	0 05	0 06
TiO ₂	0 94	0 93	1 43	1 25
P ₂ O ₅	0 22	0 20	0 18	0 11
MnO	0 08	0 09	0 09	0 06
	100 03	99 84	100 72	100 79

Norms

	(1)	(2)	(3)	(4)
Q	28 26	26 52	22 02	27 72
Or	22 80	22 24	31 14	27 24
Ab	28 82	31 44	28 30	24 63
An	10 56	11 40	9 45	11 95
C	1 43	0 92	-	0 51
Hy	4 93	4 77	5 47	5 41
Mt	0 23	—	0 93	0 46
Il	1 82	1 82	2 74	2 43
Ap	0 67	0 34	0 34	0 34

(1) Biotite granite, I'' 4 2 3''. Villalba, Madrid Province

(2) Biotite granite, I'' 4 2 3(4) Barrocal de Cerceda, Madrid Province

(3) Biotite granite I(II) 4.2.3 Almorox, Toledo Province

(4) Biotite granite, I'' 4 2.3 Baños de Panticosa-Pirenes, Huesca Province

H S WASHINGTON, analyst

of black biotite. No muscovite is visible. They differ in granularity: those from Villalba and Barrocal de Cerceda, in the Sierra de Guadarrama, are 2 to 5 millimeter-grained; that from Baños de Panticosa, in Huesca, is finer, 1 to 2 millimeter-grained; and one from Almorox, northwest of Toledo, is coarser and somewhat porphyritic.

and is not quite fresh. The thin sections show typically granitic texture, all the rocks being made up of very slightly turbid orthoclase with a little oligoclase, considerable quartz, and a little pale brown biotite. No muscovite was seen in any of the sections. There are a few small zircons and rare prismoids of apatite, but no magnetite or epidote. There is no hornblende.

A specimen of rather coarse granite from Cercedilla, north of Madrid, with flesh-red feldspar and very little quartz, is too much weathered to merit further description or analysis.

The analyses presented in Table 1 are of interest as showing great uniformity in chemical composition. The variation in percentage of SiO_2 is within 2 per cent, and the amounts of the other constituents differ only slightly the one from the other. The percentage of K_2O is higher than that of Na_2O , but not very much so, while the amount of CaO is considerable and fairly constant. The norms show the absence of the diopside molecule, and the presence of hypersthene and (in Nos. 1, 2, and 3) corundum, these features being in harmony with the presence of biotite alone as the mafic mineral, and the absence of hornblende or augite.

It is clear, from the microscopical examination and from the analyses and norms, that these granites are not alkalic, but are calci-alkalic, and sodiopotassic, as is shown by the symbol, 1.4.2.3, of the rang in which they fall. This calci-alkalic character is in line with the fact that in the central plateau "quartz porphyry," quartz diorite, diorite, and diabase are common, although much less abundant than granite, while per-alkalic and very sodic rocks, such as syenite, nephelite syenite, and tinguaita, are very rare or are unknown.

These analyses of granite give an idea of the general magmatic character of the Iberian Meseta, especially when the great uniformity among the specimens from different localities is considered, and when the granites are taken in connection with the associated rocks. It is clear that the magmatic character of the great central Spanish horst differs very much from that of the igneous (plutonic and volcanic) areas that occur on and near the coasts, on all sides around the central mass. Many of these have been studied petrographically, with chemical analyses, and they are fairly well known. They are alkalic or sub-alkalic, and mostly with a decidedly sodic character. They include: the granites of Guipuzcoa⁷ and the trachyte, etc., of Monte

⁷ THÉMINIER, Bull. Soc. Geol. France 7: 13. 1907.

Axpe near Bilbao,⁸ on the north; the volcanoes of Olot and Gerona,⁹ with basalt, nephelite basanite, and limburgite, at the northeast; the rhyolites, dacites and andesites of Cabo da Gata¹⁰ and the peculiar alkalic rocks of Murcia,¹¹ in the southeast; the nephelite syenite mass, with its accompanying dikes in Algarve, Portugal,¹² at the southwest; and the riebeckite syenite mass of Alter Pedroso, in Alemtejo,¹³ on the west.

Fernandez Navarro¹⁴ has shown that recent lavas do not occur in the central meseta, except for one small occurrence of nephelite basalt in the Sierra de Guadarrama, but that a series of Tertiary and more recent small eruptions of nephelite basalt and of limburgite have taken place along its periphery. He also points out some of the coastal occurrences of more varied rocks.

It thus appears that, petrologically, the Iberian Peninsula consists essentially of a main central massif of dominantly granitic rocks, of approximately average composition, surrounded on its folded and faulted borders by discontinuous occurrences of more alkalic, and mostly sodic, igneous rocks. In these respects it does not appear to be unique, but is analogous to several other horsts, as well as some of the ancient shields, and even some of the continental masses.

The matter cannot be discussed fully in this brief note, but a few examples may be given.¹⁵ These include: the Canadian shield, with alkalic rocks in Ontario and Quebec; the Brazilian shield, with alkalic rocks in eastern Brazil and Paraguay; the Fenno-Scandian shield, with alkalic rocks at Christiania, Kola, and elsewhere; and apparently the continent of Africa, where the coastal igneous rocks are mostly sodic, while the interior is largely granitic.

Such distribution of distinctly sodic rocks around a central granitic massif, if it be indeed real, brings to mind Harker's hypothesis of differentiation by expulsion of residual magma through crustal stresses, with the production of alkalic, and especially sodic, rocks. It would not be favorable to the reference of igneous rocks to Atlantic and Pacific branches, nor to belief in the derivation of alkalic rocks from basaltic ones by assimilation of limestones.

⁸ WASHINGTON, U. S. Geol. Survey, Prof. Paper 99: 271. 1917.

⁹ CALDERON, CAZURRO, and NAVARRO, Mem. Soc. Espan. Hist. Nat. 4, 5: 1907; WASHINGTON, Amer. Journ. Sci. 24: 217. 1907.

¹⁰ OBANN, Zeitschr. deutsch. geol. Ges. 43: 325, 688. 1891.

¹¹ OBANN, Rosenbusch Festschr. 263. 1906.

¹² KRATZ-KOSCHLAU and HACKMANN, Tech. Min. Pet. Mitth. 16: 197. 1896.

¹³ LACROIX, Compt. Rend. Acad. Sci. 163: 279. 1918.

¹⁴ FERNANDEZ NAVARRO, Compt. Rend. Acad. Sci. 162: 252. 1916.

¹⁵ The distribution suggested here was briefly alluded to in CLARKE and WASHINGTON, U. S. Geol. Survey, Prof. Paper 127: 43, 53, 55, 63. 1924.

BOTANY.—*The genus Calatola.*¹ PAUL C. STANDLEY, U. S. National Museum.

In 1923 the writer published in the *Trees and Shrubs of Mexico*² a new genus of Mexican trees, *Calatola*, which was referred doubtfully to the family *Icacinaceae*. It had been intended to publish previously a fuller account of the genus, with an illustration of one of the species, and a description of a third species, native of Costa Rica, but the publication of the paper was delayed. During a visit to Costa Rica in 1925-26 further material of the Costa Rican tree was obtained, together with interesting data concerning its economic applications. The purpose of the present paper is to give an account of the information now available with regard to the genus.

CALATOLA Standl. Contr. U. S. Nat. Herb. 23: 688. 1923.

Trees; leaves alternate, petiolate, the blades membranaceous or coriaceous, entire; flowers dioecious, very small, the staminate bracteate, arranged in long slender solitary axillary spikes, the pistillate axillary, solitary and pedunculate or in few-flowered spikelike inflorescences; calyx of the staminate flower small, 4-lobate, corolla of the staminate flowers 4-parted, the lobes concave, valvate, 1-costate on the inner surface and sparsely villous along the costa; stamens 4, alternate with the corolla lobes, erect, basifixed, the filaments very short, adnate to the corolla, the anthers oblong, 2-celled, dehiscent by lateral slits; calyx of the pistillate flower 4-lobate; ovary 1-celled; fruit drupaceous, large, globose, oval, or obovoid, the flesh thick, the stone thick and osseous, bicristate and with numerous irregular reticulate dentate crests over the whole surface; seed large, the surface irregularly convolute, the embryo large, the endosperm copious, fleshy.

Type species, *Calatola mollis* Standl.

In flower characters the genus seems to agree reasonably well with the family *Icacinaceae*, but in general appearance it does not much resemble other members of the family. The strictly spicate character of the staminate spikes, which strongly suggest catkins, is not matched in other genera of the *Icacinaceae*, and the fruit also exhibits certain peculiarities. The flowers, however, are much like those of the common representatives of the family. Among the American genera, the only ones that appear to be related are *Mappia* and *Kummeria*, both of which differ in their long filaments and 5-parted flowers.

Although the material at hand is rather ample, the result of its study has been far from satisfactory, and study of the trees in the forest has failed to give a better clue to their relationship. It may be that further study will

¹ Published by permission of the Secretary of the Smithsonian Institution. Received July 29, 1926.

² Contr. U. S. Nat. Herb. 23: 688. 1923.

necessitate the reference of the genus *Calatola* to some other family, or even its recognition as the type of a distinct family.

The generic name *Calatola* is the vernacular name of one of the Mexican species.

It is of interest to record here the fact that Dr. E. W. Berry has published² recently the description of a genus, *Calatoloides*, based upon fossil fruits from the Wilcox Group of the lower Eocene strata of southwestern Texas. Dr. Berry states that, so far as he is aware, no representative of the family *Icacinaceae* has ever before been found fossil. The fruit of *Calatoloides eocenicum*, as figured, is strikingly like that of the genus *Calatola*, but only half as large.

KEY TO THE SPECIES

Leaves densely soft-pubescent beneath over the whole surface.

1. *C. mollis*.

Leaves glabrous beneath, or densely barbate in the axils of the lateral nerves.

Leaves glabrous beneath or nearly so, not at all barbate; staminate spikes very dense. 2. *C. laevigata*.

Leaves densely barbate beneath in the axils of the lateral nerves; staminate spikes loosely flowered and somewhat interrupted.

3. *C. costaricensis*.

1. *CALATOLA MOLLIS* Standl. Contr. U. S. Nat. Herb. 23: 689. 1923.

Fig. 1.

Tree, the branches terete, densely pilose when young with short fulvous-grayish hairs; petioles stout, 3-4.5 cm. long, pilose; leaf blades oval-elliptic, oblong-oval, or oblong-obovate, 21-30 cm. long, 8-14 cm. wide, obtuse or rounded at base, acute or abruptly short-acuminate at apex, when young short-pilose on the upper surface but soon glabrate except along the nerves, densely short-pilose beneath, the costa slender, prominent, the lateral nerves 7-9 on each side, ascending at an angle of about 50°, subarcuate, laxly anastomosing near the margin; staminate spikes 8-21 cm. long, about 6 mm. in diameter, densely flowered, the rachis short-pilose, the bracts small, ovate-acuminate; calyx densely white-pilose outside, glabrous within, the lobes oblong-oval, obtuse; corolla 2 mm. long, the lobes obtuse, sparsely villous outside along the costa; anthers 1.2 mm. long, the filaments about 0.3 mm. long; pistillate flowers solitary; peduncle of the fruit (in one immature specimen) 1.5 cm. long; fruit densely and closely tomentose, the stone 5-5.5 cm. long, 4-4.5 cm. in diameter, covered outside with very numerous thin, sharp, irregularly dentate, reticulate crests, smooth and brown within; seed about 3 cm. long, brownish.

MEXICO: Zacatlán, Puebla, Apr. 3, 1913, *F. Salazar*, type. Tlatlanquitepec, Distrito de Tepeji, Puebla, collector unknown.

This tree is well known in the State of Puebla, and has been mentioned a few times in literature, but without a Latin name. It has been referred in at least one instance to the *Juglandaceae*, doubtless because of the nutlike fruits, which somewhat suggest walnuts. The staminate spikes, likewise,

² *Additions to the flora of the Wilcox Group*, U. S. Geol. Surv. Prof. Paper 131: 14. pl. 14, f 3-5. 1923.

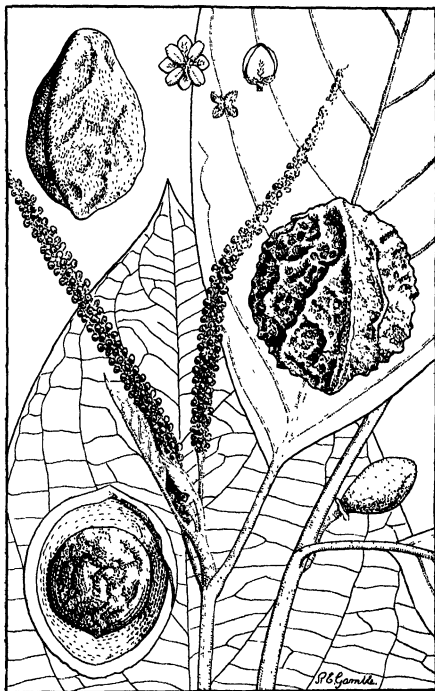


Fig. 1.—*Calatola mollis*. Natural size; floral details $\times 2$.

resemble catkins. The vernacular name of the tree is "calatola;" the fruits are called "nueces de calatola."

Here probably belong specimens of fruits, received from Prof. C. Conzatti, who writes of them as follows: "I send two fruits called 'nuez de calatola.' The plant which bears them is a tree about 20 meters high, called 'calatolazno,' native of Tlatlanqui, Distrito de Zacapoaxtla, Puebla. It grows at an altitude of 650 to 900 meters. It flowers in March and April, and the inflorescences, which I have not seen, are called 'colas de ratas.' The seeds are said to have vomitive-purgative properties."

According to notes made by Dr. W. E. Safford, this tree has been reported from Tabasco and San Luis Potosí, and the name "zapote de mono" sometimes is given to it. The seeds are said to have been employed with good results as a purgative. They are reported to yield a clear yellow oil, and drops of a blue coloring matter which is partly soluble in water or alcohol. It is said that the seeds are sometimes employed for dyeing.

2. *CALATOLA LAEVIGATA* Standl. Contr. U. S. Nat. Herb. 23: 689. 1923.

Branchlets sparsely appressed-pilose or glabrate; petioles 1.5–2 cm. long; leaf blades oblong or narrowly elliptic-oblong, 11.5–16 cm. long, 4–7 cm. wide, acute or obtuse at base, acute at apex, when young sparsely puberulent along the costa but soon glabrous, subcoriaceous, usually drying blackish, entire or obscurely sinuate-serrate, the costa prominent beneath, the lateral nerves about 10 on each side, very slender, arcuate, staminate spikes sessile, 4–6 cm. long (immature; probably much longer in anthesis), very dense, the bracts ovate-acuminate, equaling the flower buds, sericeous; calyx minutely sericeous outside, the lobes obtuse, corolla lobes obtuse, glabrous outside; pistillate flowers in short dense spikes, young fruit sparsely short-sericeous or nearly glabrous.

MEXICO. Cafetal San Carlos, Cerro Espino, Oaxaca, alt. 800 m., *B. P. Reko* 3440, type. Cafetal Calvario, Cerro Espino, Oaxaca, *Reko* 3728.

Calatola laevigata has much narrower leaves than *C. mollis*, and denser staminate spikes. The vernacular name is "palo tinta," from which it may be surmised that the fruits are employed for dyeing.

3. *Calatola costaricensis* Standl., sp. nov.

Tree 6–15 m. high or larger, with a dense, broad or sometimes narrow crown, branchlets and petioles pilose with minute, appressed or ascending, ochraceous hairs, in age glabrate, petioles 2–5 cm. long; leaf blades oblong or elliptic-oblong, 10–25 cm. long, 4.5–10.5 cm. wide, short-acuminate to obtuse, acute at base, somewhat lustrous when fresh but when dry dull and usually blackish, when young sparsely appressed-pubescent above but soon glabrate, beneath densely barbate along the costa, especially in the axils of the nerves, the lateral nerves 6–8 on each side, subarcuate, laxly anastomosing near the margin; staminate spikes about 13 cm. long, very slender and laxly flowered, the rachis hirtellous; calyx hirtellous outside, the lobes obtuse; fruit oval, 5–7 cm. long, glabrous or nearly so, smooth, green, with thick juicy flesh; stone ellipsoid to subglobose, 4.5–6.5 cm. long, 3.5–4 cm. in diameter, rounded or obtuse at each end, bicristate and also with several sharp longitudinal crests and numerous transverse reticulate crests.

Type in the U. S. National Herbarium, no. 1,251,510, collected in wet forest at Yerba Buena, northeast of San Isidro, Provincia de Heredia, Costa Rica, altitude about 2,000 meters, February 28, 1926, by Paul C. Standley and Juvenal Valerio (no. 50,000). The following collections also belong here:

COSTA RICA: Forests of El Copey, alt. 1,800 m., Tonduz 11896. Viento Fresco, Provincia de Alajuela, alt. 1,800 m., Standley & Torres 47895. Santa María de Dota, Provincia de San José, alt. 1,500 m., Standley 42838, Standley & Valerio 43359. Near Quebradillas, Provincia de San José, Standley 42865. Cerro de las Caricias, Provincia de Heredia, alt. 2,000 m., Standley & Valerio 51943. Yerba Buena, Standley & Valerio 49028.

Here may be referred also two stones received from Dr. F. W. Berry, who found them on the beach in Panama at Panama and San Miguel bays. These stones may have come from Panama or Costa Rica, or possibly, of course, from some other region. It is to be expected that some species of the genus will be found in the mountains of northern Panama.

Calatola costaricensis is a frequent tree in the mountains of central Costa Rica, growing in moist or wet forest at altitudes of 1,500 to 2,000 meters. It is a large tree with rather smooth but scaly bark, and there is nothing about its appearance to attract attention. The curious fruits, which often are abundant upon the ground, are noticed immediately, however, for they are quite unlike any other with which one is familiar.

The tree first came to my attention this year at Santa María, where it was rather common. The fruits were shown to several persons, all of whom knew them, but were uncertain as to their name. The name "duraznillo" was given by some, but this is probably incorrect, although the stones do suggest somewhat peach pits, as that name would indicate. I was given also the name "crepe," and this is probably correct, since it is reported also by Tonduz from El Copey.

On the slopes of the volcanoes of Barba and Poás the tree is well known, and called "palo de papa" (potato tree), "papa de palo," and "palo azul." I was told at Fraijanes that *palo de papa* and *palo azul* were different trees, but a guide, to whom fruits were shown, said they were those of *palo azul*, while he gave the name *palo de papa* for the dry stones from which the flesh had been stripped. The name *palo azul* probably refers to the fact that the leaves often have a bluish cast, or perhaps to the fact that, as in *C. mollis*, a blue coloring material is found in the seeds, although I did not note any blue coloration in the seeds that we examined.

The wood of this tree is said to be of good quality and to be used sometimes for construction purposes. The most important and interesting product of the tree is the seeds. They are white, of firm consistency, and have a pleasant sweet flavor suggesting coconut. By the people who live on the slopes of Barba and Poás the seeds are roasted and eaten. They are also ground and mixed in tortillas, the tortillas thus made having the agreeable flavor of those prepared with grated cheese.

Prof. Valerio and myself ate some of the fresh seeds found at Yerba Buena,

and found them very good. We also ate roasted seeds, but found them less agreeable, perhaps because they had not been roasted properly.

While Mr. H. Pittier was in Washington recently, *Calatola* seeds were shown him. He recognized them immediately, and recounted that once, while lost in the mountains of Costa Rica, and without food, he ate some of the seeds and was made very sick by them. It seems probable, therefore, that the seeds of *C. costaricensis* possess the properties ascribed to those of the Mexican species.

The stones of *Calatola costaricensis* exhibit considerable variation in size and form, those from the region of Santa María being longer and narrower than those from the central cordillera. It may be that when more ample material has been assembled, it will be found that two species are represented in Costa Rica.

BOTANY.—*Five new American Melampodiinae.*¹ S. F. BLAKE,
Bureau of Plant Industry.

This paper contains descriptions of five new tropical American *Asteraceae* of the subtribe *Melampodiinae*, as well as a record of range extension for a unique species of *Ichthyothere* described in this Journal several years ago.

Clibadium laxum Blake, sp. nov.

Section *Euchbadium*; plant strigillose; leaves large, ovate, long-petioled, serrate, submembranous; heads medium-sized, remote, in very loose divergent-branched panicles, phyllaries 1-2, pistillate flowers 9, hermaphrodite 10-13; fertile ovaries pubescent at apex.

"Branched herb, 2-2.5 m. high;" stem stout (7 mm. thick above), pithy, indistinctly about 6-angled, rather densely short-strigose; leaves opposite, those subtending the upper branches of the inflorescence alternate; petioles strigillose, sulcate above, margined above by the decurrent leaf blades, the naked portion 2.5-9 cm. long; blades ovate, those below the inflorescence more broadly so, 23.5 cm. long, 15 cm. wide, acuminate, at base truncate-rounded and shortly decurrent on the petiole, those subtending the principal branches of the inflorescence long-acuminate, cuneate at base, 14-20 cm. long, 6-9 cm. wide, all thin, nearly equally green on both sides, coarsely and bluntly serrate (teeth mucronulate-tipped, depressed, 2-3 per cm.), lepidote-strigillose and barely roughish above (the hairs mostly deciduous except for the bases), sparsely strigillose beneath, tripli- or quinquelinerved within 4.5 cm. of base, the veins prominent beneath, the principal veinlets prominulous; panicles many-headed, very loose, ternately divided, about 17 cm. wide, strigillose, on peduncles 8 cm. long or less, the bracts subulate-filiform, 2-6 mm. long; heads sessile, remote (usually 3-10 mm. apart), in flower oblong, 6 mm. long, 3.5 mm. thick, in fruit depressed-globose, 3.5 mm. long, 4.5 mm. thick; phyllaries 1 or 2, ovate to suborbicular-ovate, 3 mm. long, 2.2 mm. wide, acutish to obtuse, 5-7-nerved, ciliate, sparsely strigillose, whitish, subscarious; pistillate flowers 9, all paleate, the hermaphrodite 10-13, all but the 2 or 3

¹ Received July 30, 1926.

innermost paleate; pales of the pistillate flowers suborbiculate-ovate, up to 4 mm. long, 2.8 mm. wide, acutish or obtuse, about 6-nerved; pales of the hermaphrodite flowers oval-oblong, blunt, 1.8-2.8 mm. long, 3-5-nerved, ciliate; pistillate corollas white, obscurely glandular at apex, unequally 3-toothed, 2 mm. long; hermaphrodite corollas white, 3.2 mm. long, hispidulous on the teeth; achenes suborbicular-obovoid, 1.8-2 mm. long, 1.6-1.8 mm. wide, obcompressed, fuscous, hispidulous at apex; sterile ovaries long-pilose especially toward apex, 1-1.2 mm. long.

ECUADOR: Teresita, 3 kilometers west of Bucay, Province of Guayas, altitude 270 meters, 5-7 July 1923, A. S. Hitchcock 20430 (TYPE no. 1,195,383, U. S. Nat. Herb.).

The only close ally of this species is *Clibadium remotiflorum* O. E. Schulz, of Brazil and Bolivia, which has 4 or 5 phyllaries, larger heads, smaller leaves, and shorter petioles.

***Clibadium microcephalum* Blake, sp. nov.**

Section *Euchbadium*; plant strigillose; leaves large, ovate, long-petioled, membranous, depressed-serrate; heads tiny, sessile or subsessile, crowded in small glomerules; pistillate flowers 3, hermaphrodite 3-4; fertile ovaries pubescent at apex.

"Shrub;" stem subangulate, striatulate, strigillose, 5 mm. thick just below the inflorescence; leaves (only uppermost seen) subopposite; petioles strigillose, margined above by the narrowly decurrent leaf blades, the naked portion 4-5 cm. long; blades ovate, 24-28 cm. long, 11.5-14 cm. wide, acuminate, cuneate or cuneate-rounded at base and then narrowly decurrent on the upper part of the petiole, depressed-serrate (teeth mucronulate-tipped, 1-3 per cm.), about equally green on both sides and sparsely strigillose, roughish above and there with the hairs mostly deciduous except for their lepidote bases, quintuplinerved within about 4 cm. of base, the principal veinlets prominulous beneath, scarcely so above; panicles ternate at apex of stem, many-headed, flattish, 7-10.5 cm. wide, densely strigillose, ternately divided, on peduncles 3.5-11 cm. long, the heads in glomerules of 5-8, these mostly 4-7 mm. thick; bracts mostly subulate and about 2 mm. long; heads oblong-cylindric, 5 mm. long (including the corollas) 2 mm. thick; phyllaries 2 or 3, suborbicular-ovate, obtuse, 3-6-nerved, subscarious, ciliate, essentially glabrous dorsally, 2.5-3 mm. long, 2-2.8 mm. wide, sometimes with a much smaller triangular-ovate acutish bractlet at base; pistillate flowers 3, all paleate, the hermaphrodite 3 or 4, usually epaleate, rarely 2 paleate; pales of the pistillate flowers similar to the phyllaries; pistillate corollas white, glabrous, minutely 4-toothed, 2.2 mm. long; hermaphrodite corollas white, finely hispidulous on the teeth, 3.2 mm. long; submature fertile ovaries obovoid, obcompressed, hispidulous above, 2 mm. long, 1.2 mm. wide; sterile ovaries ascending-pilose throughout, 2 mm. long.

ECUADOR: Valley of Pastaza River, between Baños and Cashuro, Province of Tungurahua, altitude 1300-1800 meters, 25 Sept. 1923, A. S. Hitchcock 21873 (TYPE no. 1,195,714, U. S. Nat. Herb.).

Nearest *Clibadium glomeratum* Greenm., of Costa Rica, which is immediately distinguished by its pilose-tomentose branches and inflorescence.

***Ichthyothere connata* Blake, sp. nov.**

Glabrous throughout; leaves opposite, ovate, sessile, conspicuously connate

at base, entire, thick, 7 or 9-plinerved; heads few, sessile in a terminal cluster; pales with erose acutish tips.

Herbaceous, simple or subsimple, 35 cm. high and more; stem stout (3-5 mm. thick), striate-angled, apparently glaucescent, internodes 3-7 cm. long, usually shorter than the leaves; leaves ovate or oval-ovate, 5.5-8 cm. long, 3-4.2 cm. wide, not reduced above, acute, at base clasping and connate for 2-6 mm., stiffly coriaceous, 7 or 9-plinerved from base and prominulous-reticulate, apparently glaucescent; heads about 7 mm. high, 5 mm. thick, about 3 or 4 in a terminal cluster, subtended by normal leaves; phyllaries suborbicular, obtuse, glabrous, strongly about 10-ribbed, the narrow thin margins erose above with subglandular teeth; pales acutish, subglandular-erose, strongly about 3-nerved.

BRAZIL: "Chapadao dos Veadeiros ou de Porto Leguro," Goyaz, Jan.-Feb. 18—, *A. Glaziou* 21648 (type in Kew Herb.; photograph and fragment, U. S. Nat. Herb.)

A very distinct species, nearest *Ichthyothere latifolia* (Benth.) Gardn.,³ but readily distinguished by its conspicuously connate-clasping leaves. The type number was listed by Glaziou² as *I. suffruticosa* Gardn., a species with elongate-lanceolate leaves. The sheet examined, on loan from the Kew Herbarium, now bears only two heads, which it has not seemed advisable to injure by dissecting. The stem and leaves appear to have been glaucous, but this appearance may be due to the deposition of a very thin layer of the corrosive sublimate used in poisoning.

ICHTHYOTHERE SCANDENS Blake, Journ. Washington Acad. Sci. 11: 301 fig. 1. 1921.

This species, originally described from a collection (no. 3430) made by Dr. F. W. Pennell at Labano, Department of Tolima, Colombia, altitude 1100-1300 meters, in 1917, has since been found to have an extensive range. It was collected many years ago at Colonia Tovar, Venezuela, by Fendler (no. 2560, in Gray Herb.), and has been found several times by Mr. Henry Pittier in Venezuela (as at El Portachuelo, State of Miranda). Prof. A. S. Hitchcock collected it (no. 21881) in the valley of the Pastaza River, 8 hours east of Baños, Province of Tungurahua, Ecuador, alt. 1300-1800 meters, on 25 Sept. 1923. A most unexpected extension of range is shown by typical specimens collected in the vicinity of Guápiles, Province of Limón, Costa Rica, alt. 300-500 meters, 12-13 March 1924, by Mr. Paul C. Standley (no. 37148). The last occurrence establishes the first record for the genus outside the South American continent.

The original specimen was described by the collector as a shrubby vine. Later collectors have called it a shrub or herb 4-5 ft. high. It is probable that this species varies in habit, like many other tropical plants.

³ This name, based on *Latreillea latifolia* Benth., was properly published by GARDNER, Lond. Journ. Bot 7: 424 1848. The specimen listed (but not described), Gardner 3273, belongs to *I. terminalis* (Spreng) Blake (*I. cunabi* Mart.). BAKER, Fl. Bras 6: 154. 1884, has referred Gardner's name to the synonymy of *I. cunabi*, and remade the combination *I. latifolia* for Benthams plant.

² Mém Soc Bot France 3: 409 1910

***Polymnia latiscuama* Blake, sp. nov.**

Tall herb; stem essentially glabrous; leaves ovate, large, firm-papery, coarsely serrate, triplinerved, short-decurrent on the upper part of the petiole; heads solitary, long-peduncled; outer phyllaries 4, ciliolate, glabrous dorsally, suborbicular-ovate, about 1.8 cm. wide; rays yellow, about 8, the lamina about 3 cm. long.

Herb, 1.5-3 m. high; stem rather slender (2.5-3.5 mm. thick), simple or dichotomous at apex, striatulate; upper internodes 5.5-9 cm. long, leaves opposite; petioles cuneate-winged at apex, hirsute-pilose with sordid many-celled hairs, narrowly connate at base, the naked portion 1-4.5 cm. long; leaves ovate or the lower triangular-ovate, 9-23 cm. long, 4.5-15 cm. wide, acuminate, often slightly falcate, at base cuneate to (in the larger leaves) subtruncate, decurrent on the petiole for 0.5-2.2 cm., coarsely serrate with unequal teeth (1-3 per cm.) tipped with blunt somewhat callous mucros about 0.5 mm. long, above deep green, smooth, essentially glabrous, hirsute-ciliate with sordid many-celled hairs, beneath scarcely lighter green, glabrous or with a few hairs along the veins, triplinerved and beneath prominulous-reticulate; peduncles solitary, terminal, glabrous, naked, 7-9 cm. long, heads about 6 cm. wide; disk 2-2.5 cm. thick; outer phyllaries 4, decussate, suborbicular-ovate, obtuse to acute, coriaceous, sparsely hirsute-ciliate, glabrous dorsally, about 9-nerved, united for about 5 mm. at base, subcordate, 2-2.3 cm. long (from base of involucre), 1.7-2 cm. wide; inner phyllaries (subtending the rays) about 8, ovate, short-acuminate, submembranous, ciliate, stipitate-glandular on back, at maturity about 13 mm. long, 8 mm. wide; rays "bright yellow," pilose on tube and on nerves of back, fertile, the tube about 1.5 mm. long, the lamina oblong-elliptic, 3.5 cm. long, 9 mm. wide; disk flowers very numerous, infertile, their corollas yellow, sparsely hirsute on tube, 1 cm. long (tube 2.5 mm., throat thick-cylindric, 5 mm., teeth ovate, papillose-margined, 2 mm. long); pales oblong, membranous, obtuse, bluntly 1-dentate on each side below apex, somewhat pilose and stipitate-glandular, about 6-nerved, 9 mm. long, 3 mm. wide; ray achenes (scarcely mature) plump, obcompressed, glabrous, multistriatulate especially on back, epappose, 6 mm. long, 5 mm. wide; style of disk flowers 2-parted, the branches densely hirsute-pilose, with linear subulate hispidulous appendages.

COSTA RICA. Along stream, southern slope of Volcán de Turrialba, near the Finca del Volcán de Turrialba, alt. 2,000-2,400 meters, 22 Feb. 1924, *P. C. Standley* 35340 (TYPE no. 1,227,055, U. S. Nat. Herb.); wet thicket, Río Burris, southern slope of Volcán de Irazú, 23 Feb. 1924, *Standley* 35412.

The closest relative of this species is *Polymnia guichensis* Coulter, of Guatemala, which has more or less densely sordid-pilose stem and peduncles, narrower leaves with more tapering base, rough above and rather densely sordid-pilose on the veins and veinlets beneath, smaller, ovate, acuminate phyllaries (1-1.5 cm. long, 8-9 mm. wide), and much shorter rays (lamina about 1.2 cm. long).

***Melampodium cornutum* Blake, sp. nov.**

Slender annual; stem hirsutulous in lines, without long hairs; leaves slender-petioled, rhombic-ovate, crenate-serrate, membranous; heads small, sessile or subsessile, axillary and terminal; phyllaries 5, free nearly to base; rays minute; fruit with ovate appendage prolonged into a long slender recurved horn.

Plant about 15 cm. high, few-branched above, the branches long and divergent; leaves opposite; petioles of the larger leaves slender, 8-13 mm. long, narrowly marginate above, hirsutulous on margin; blades of the larger leaves rhombio-ovate, 2-3.2 cm. long, 1.2-2.3 cm. wide, acute, acutely cuneate at base, crenate-serrate above the entire cuneate base (teeth 5-7 pairs), triplinerved, sparsely hirsute-pilose above and on margin, beneath scarcely paler and practically glabrous; branch leaves smaller, short-petioled, often obtuse; heads about 4 mm. wide in anthesis; outer phyllaries 5, oval or oval-oblong, membranous-herbaceous, free nearly to base, obtuse or rounded, ciliate, about 5-nerved, 2-2.5 mm. long, 1.2-1.8 mm. wide; rays probably 5, greenish-yellow, bidentate, 3-nerved, about 1.3 mm. long, much shorter than the body of the fruit appendage; disk flowers about 3, their corollas greenish yellow, 1.3 mm. long, 4 or 5-toothed, the teeth bearing an internal apical tuft of hairs; pales oval, obtuse, scarious, glabrous, 1.3 mm. long, bearing a subterminal oblong central gland; fruit body ribbed and corrugate on the sides, about 1.5 mm. long, 1.3 mm. wide, the hood ovate, sparsely hispidulous-ciliate, sometimes mucous, obtuse, and about 1.2 mm. long, usually acuminate, about 2 mm. long and 1.6 mm. wide, and prolonged into a slender recurved sparsely hispidulous horn about 3.5 mm. long.

MEXICO: Alzada, Colima, 4 Nov. 1910, C. R. Orcutt 6601 (TYPE no. 1,209,590, U. S. Nat. Herb.).

Related to *Melampodium longicornu* A. Gray, which has similar heads and fruit, but is distinguished by its narrowly elliptic to lance-elliptic, sessile or subsessile leaves.

BOTANY.—Venezuelan species of *Valeriana*, section *Porteria*.¹ H.

PITTIER, Caracas, Venezuela, and E. P. KILLIP, U. S. National Museum.

Two genera of the family Valerianaceae, *Porteria* Hook. and *Amblyorhinum* Turcz., were proposed in the year 1852, the former antedating the latter by a few months. A single species, *Porteria bractescens*, was described² by Hooker; five species were published³ under *Amblyorhinum*. Both Hooker's *P. bractescens* and the first species mentioned under *Amblyorhinum* by Turczaninow, *A. grandiflorum*, which should be considered the type of this genus, were based on Linden's 424, from Caracas. Turczaninow, after he had prepared the manuscript of his paper, evidently became aware of Hooker's article, for he added a paragraph (p. 173) in which he changed the name of his first species to *Porteria bractescens*, and transferred the five other species to *Porteria*.

The characters which Hooker especially emphasizes in describing *Porteria* are the large imbricate bracts which almost completely con-

¹ Received July 3, 1926. Published by permission of the Secretary of the Smithsonian Institution.

² Hook. Icon. Pl. 9: pl. 864. 1852.

³ Bull. Soc. Nat. Moscou. 26: 173. 1852.

ceal the flowers, the bract-like leaves, the truncate, saucer-shaped epappose calyx-limb, inclined to the side, the attachment of the corolla laterally, its base forming a blunt spur, and, finally, the general shrubby aspect of the plant.

In an account⁴ of South American Valerianaceae published in 1857, Weddell, evidently unaware of Turczaninow's work, described three new species in the genus *Phyllactis* Pers. (Group B), one of which, *Phyllactis cordifolia*, was based on Funck and Schlim's 1623, the type of *Amblyorhinum* (= *Porteria*) *spicatum* Turcz. The two other species were *Phyllactis mutisiana* and *P. pinnatifida*, both from Colombia.

As originally understood by Persoon,⁵ *Phyllactis* included only stemless plants, with rosette leaves, involucrate flowers having a 3-lobed corolla, and epappose fruit. The extension of *Phyllactis*, either as a distinct genus or as subgenus of *Valeriana*, to include the species which we are discussing, is hardly justifiable.

Höck, in an elaborate monograph⁶ of Valerianaceae, reunited *Phyllactis* and *Valeriana*, dividing the species enumerated by Weddell under *Phyllactis* among four sections. In the section *Porteria* was placed correctly *Valeriana bractescens* (Hook.) Höck; but Höck unfortunately included certain Ecuadorean species with a well-developed, pappose calyx.

Graebner's synopsis of Valerianaceae⁷ contributed little to the correct interpretation of this particular group, for in his section of *Valeriana* to which he gave the name *Porteria* not a single one of the species originally described by Hooker or Turczaninow was mentioned.

It remained for Briquet in 1914⁸ to formulate the most satisfactory interpretation of this group, and, in the main, the present paper is in accord with his treatment.

The question as to whether this small group of species, confined probably to the mountainous region of western Venezuela and eastern Colombia, constitutes a genus distinct from *Valeriana* or whether it is treated best as a well-marked section is difficult to determine at present. The calyx of *Valeriana* (wide sense) varies greatly, and these variations are not clearly associated with other characters. The spur near the base of the corolla tube, prominent in the original

⁴ *Chloris Andina* 2: 23. 1857.

⁵ *Syn.* 1: 39. 1805.

⁶ *Bot. Jahrb. Engler* 3: 57. 1882.

⁷ *Bot. Jahrb. Engler* 37: 445, 476. 1906.

⁸ *Ann. Conserv. Jard. Bot. Genève* 17: 340-356. 1914.

species of the group, is much reduced in the other species; in at least two species it is scarcely more pronounced than in *Valeriana rusbyi*, *V. simplex*, *V. lyrata*, or *V. urticifolia* of various other sections. As Briquet observes, a restoration of the genus *Porteria* should be made only in a general monograph of Valerianaceae, based upon a complete study of the material in the large herbaria.

Recently certain species of this group have been re-collected in Venezuela, thus supplying data additional to those in Briquet's synopsis, and one new species has been found. It seems advisable to publish this information at the present time. Mr. Killip has had the opportunity of examining material of this group in several European herbaria.

KEY TO THE VENEZUELAN SPECIES

Leaves 2.5 cm. long or less.

Leaves attenuate to a short petiole, crenulate or entire, more or less divaricate; corolla white; branches puberulent.

Corolla 6-8 mm. long; leaves crenulate, not ciliolate... 1. *V. phyllicoides*.

Corolla 4-6 mm. long; leaves entire, minutely ciliolate... 2. *V. parviflora*.

Leaves sessile, crenulate, appressed; corolla deep yellow; branches glabrous..... 3. *V. spicata*.

Leaves more than 2.5 cm. long.

Leaves serrate or crenulate; corolla 1 cm. long or less.

Bracts entire, 7 mm. long or less; leaves oblong-linear, acute

4. *V. triplinervis*.

Bracts remotely dentate, 8-10 mm long; leaves obovate-oblong

5. *V. foliosa*.

Leaves entire; corolla more than 1 cm. long.

Bracts subcordate, 2 cm. wide or more; leaves broadly lanceolate

6. *V. bractescens*.

Bracts linear-oblong, 0.5-1 cm. wide; leaves linear-lanceolate

7. *V. meridana*.

1. VALERIANA PHYLICOIDES (Turcz.) Briq. Ann. Conserv. Bot. Jard. Genève 17: 355. 1914. Fig. 1.

Amblyorhinum phyllicoides Turcz. Bull. Soc. Bot. Moscou 25^e: 171. 1852.

Porteria phyllicoides Turcz. Bull. Soc. Bot. Moscou 25^e: 173. 1852.

Porteria parviflora var. Trev. Bot. Zeit. 11: 354. 1853.

Sierra Nevada de Mérida, 3250 m., June, 1847, *Funck & Schlim* 1529 (Paris, Geneva; type). Sierra Nevada de Santo Domingo, Mérida, 3600 m., Sept. 12, 1922, *Jahn* 1092 (Caracas, U. S. N. M.). Between Caracas and Mérida, *Linden* 365, in part (Paris).

2. VALERIANA PARVIFLORA (Trev.) Höck, Bot. Jahrb. Engler 3: 57. 1882. Fig. 2.

Porteria parviflora Trev. Bot. Zeit. 11: 354. 1853.

Between Caracas and Mérida, in 1843, *Linden* 365, in part (Paris, Geneva; type). Páramo de Piedras Blancas Mérida, 4000 m., Nov. 27, 1915, *Jahn* 425 (Caracas). Páramo de Timotes, 3000-4000 m., Sept. 4, 1921, *Jahn* 547 (Caracas), Jan. 21, 1922, *Jahn* 835 (Caracas, U. S. N. M.).

Valeriana parviflora is certainly distinct from *V. phyllicoides*. The leaves are entire, usually minutely pubescent near the margin (floral leaves or bracts ciliate), and loosely imbricate; in *V. phyllicoides* they are distinctly crenulate, glabrous throughout, and closely imbricate.

In the herbarium of the Muséum d'Histoire Naturelle, Paris, there is a specimen of *Linden* 365, which corresponds excellently with the description of *V. parviflora* and with *Jahn's* 835, which was taken to Europe for comparison. On another sheet at Paris two collections are mounted, *Funck & Schlim* 1529, and another *Linden* plant, the label of which bears the same locality data as the *Linden* 365 sheet; a small slip with the number "365" is pasted on this sheet with the two specimens. The two plants appear to belong to the same species; they are not of the same species as the *Linden* 365 which is mounted by itself, they agree well with *Jahn's* 1092 which was likewise taken over for comparison. Probably *Linden* collected two distinct species under his no. 365, but possibly the slip with the number 365 has been placed wrongly on the sheet.

3. VALERIANA SPICATA (Turcz.) Briq. Ann. Conserv. Bot. Jard. Genève 17: 354. 1914. Fig. 7.

Amblyorhynchum spicatum Turcz. Bull. Soc. Bot. Moscou 25²: 170. 1852.

Porteria spicata Turcz. Bull. Soc. Bot. Moscou 25²: 173. 1852.

Phyllactis cordifolia Wedd. Chlor. And. 2: 32. 1857.

Porteria rotundifolia Karst. Fl. Columb. 2: 99. pl. 151, f. 8-10. 1862-69.

Valeriana cordifolia Hook. Bot. Jahrb. Engler 3: 54. 1882.

Sierra Nevada de Mérida, 3250 m., June, 1847, *Funck & Schlim*, 1623 (Paris, Geneva; type, also type of *Phyllactis cordifolia*). *Trujillo, Linden* 411 (Geneva).

4. VALERIANA TRIPLINERVIS (Turcz.) Briq. Ann. Conserv. Bot. Jard. Genève 17: 353. 1914. Fig. 5.

Amblyorhynchum triplinerve Turcz. Bull. Soc. Bot. Moscou 25²: 170. 1852.

Porteria triplinervis Turcz. Bull. Soc. Bot. Moscou 25²: 173. 1852.

Sierra Nevada de Mérida, Mérida, 3350 m., June, 1847, *Funck & Schlim* 1551 (Paris, Geneva; type).

5. *Valeriana foliosa* Pittier & Killip, sp. nov. Figs. 3, 4.

Planta fruticosa, trunco brevi vel brevissimo, 2-3-furcato, caulibus basi aphyllis glaberrimis, supra breve ramosis dense foliosis plus minusve rufopilosis; foliis subcoriaceis, sessilibus, semi-amplexicaulibus, obovato-oblongis, basin versus attenuatis, apice subacutis, apicem versus serratis, trinerviis nervibus penniveniis, supra glaberrimis subtus ad nervos pilosis; inflorescentius terminalibus, brevibus, dense bracteosis, bracteis ovatis, reticulatis, supra glaberrimis, lucidis, subtus ad nervos pilosis, margine sinuato-dentatis, ciliatis; bracteolis lanceolatis sparse pilosulis, interdum remote dentatis; floribus sessilibus, calyce glabro, apice limbo angustissimo minute sinuato coronato; corolla albovirescente, bracteis brevior, apice 5-lobulata, extus glabra intus sparse pilosa; staminibus inclusis; stylo apice breve trilobulato; caetera ignota.

Caulis 30-50 cm. altus, 0.5 cm. crassus. Folia 3-5 cm. longa, 0.7-1.3 cm. lata. Bractee 1.4 cm. longae, 0.8-1 cm. latae; bracteolae basi leviter

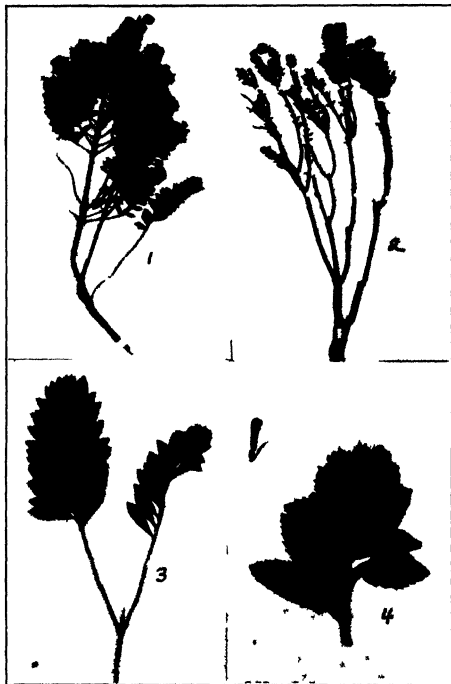


Fig 1—*Valeriana phyticoides* (Jahn 1092) 2—*V. parviflora* (Linden 365) 3 4—*V. foliosa* (type) (1 2 3 about $\frac{1}{2}$ nat size 4 1 5 nat size)



Fig 5—*Valeriana triplinervis* (F & S 1551) 6—*V. meridana* (T & S 1540) 7—*V. spicata* (F & S 1523) 8—*V. bracteucens* (Linden 424) (All about $\frac{1}{2}$ nat. size)

connatae usque ad 7.5 mm. longae, 1.4 mm. latae; calyx circa 2 mm. longus. Corolla 6-8 mm. longa.

Type in the U. S. National Herbarium, no. 1,186,558, collected on the Páramo de Quirorá, Mérida, Venezuela, altitude 3200 meters, October 8, 1921, by A. Jahn (no. 718).

This species belongs to the large-leaved group, from the other members of which it is distinguished by serrate leaves, hirsute on the nervation beneath, dentate bracts, and by the dimensions of the flower. Unfortunately, the meager specimens at hand give only a poor idea of the general appearance of the plant. Dr. Jahn describes it as being formed of two or three stems issuing from a very short trunk, or from a trunkless rootstock, and not more than 50 cm. high.

6. VALERIANA BRACTESCENS (Hook.) Hock, Bot. Jahrb. Engler 3: 57. 1882. Fig. 8.

Porteria bractescens Hook. Icon. Pl. 9: pl. 864. 1852.

Amblyorhinum grandiflorum Turcz. Bull. Soc. Bot. Moscou 25: 168. 1852.

Sierra Nevada de Mérida, 3000 m., in 1842, Linden 424 (Kew, Paris; type, also type of *Amblyorhinum grandiflorum*); Funck & Schlun 1515 (Paris, Geneva).

7. VALERIANA MERIDANA Briq. Ann. Conserv. Bot. Jard. Genève 17: 353. 1914. Fig. 6.

Amblyorhinum angustifolium Turcz. Bull. Soc. Bot. Moscou 25: 169. 1852. Not *Valeriana angustifolia* Mill., 1768.

Porteria bractescens var. Trev. Bot. Zeit. 11: 354. 1853.

Sierra Nevada de Mérida, 2800-3300 m., Funck & Schlun 1540 (Paris, Geneva; type).

In addition to these Venezuelan species, two Colombian plants, *V. mutisiana* (Wedd.) Hock and *V. karstensis* Briq. (*Porteria pubescens* Karst.), perhaps belong to this section.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

691ST MEETING

The 691st meeting of the Biological Society was held in the new assembly hall of the Cosmos Club March 27, 1926, at 8:10 p.m., with President OBERHOLSER in the chair and 80 persons present. New members elected: Mrs. MAY C. WILLIAMS SETTLE, Colonel R. MEINERTZHAGEN.

The secretary read the changes in the By-laws proposed by the committee appointed to consider this subject, consisting of H. H. T. JACKSON, Chairman, T. E. SNYDER, and B. H. SWALES. The proposed changes were passed unanimously. These changes in the By-laws are worded as follows:

That the words "The President shall not be eligible for immediate re-election" be stricken from the first paragraph, Art. II, of the By-Laws, so that the paragraph shall read: "The President shall preside at the meetings of the Society and of the Council.

He shall appoint all committees except such as are otherwise provided for; and, jointly with the Recording Secretary, shall sign all written contracts and other obligations of the Society. In the absence of the President, his duties shall be performed by one of the Vice-Presidents."

That in the first paragraph of Art. III, the word "calendar" be inserted before "year," and the words "one year" before "in" so that the paragraph shall read: "The annual dues of active and corresponding members shall be one dollar and fifty cents, payable at the beginning of the calendar year, and no member one year in arrears shall be entitled to vote at the annual meeting for the election of officers or on any proposed amendments to the Constitution or By-Laws."

That in the sixth paragraph of Art. IV, the word "December" be changed to "the spring" so that the paragraph shall read: "The annual meeting for the election of officers shall be the last stated meeting in the spring."

That the following paragraph be added to Article V: "The official term of all officers shall commence at the close of the meeting at which they are elected."

T. S. PALMER reported the first box turtles appearing from hibernation in the city on March 24 and 25, one on a southern exposure and one on a northern exposure.

ERNEST P. WALKER, Biological Survey: (*The wild life of Alaska and its protection* (illustrated).)—The work of protecting Alaska's wild life may be likened to managing a gigantic livestock range. From her most mosquito-infested swamp to the tops of her highest peaks Alaska is preeminently a livestock country. As a whole we have found no animals better suited to the range than the wild stock native to the region.

The game animals and game birds furnish much valuable meat to Alaskans and throughout the greater portion of the Territory are the only source of fresh meat. The game animals are important attractions to non-resident big game hunters and the annual fur harvest is worth about \$2,000,000, and by proper management can be increased at least tenfold with correspondingly increased profits. The waterfowl probably benefit the sportsmen of the western States even more than they do the Alaskans.

The great extent of the stock range is best illustrated by superimposing a map of Alaska on one of the United States of the same scale which places the easternmost portion at the Georgia coast and the tip of the Aleutian Islands near Los Angeles. Some lands of Alaska do not have certain game and fur animals which are well suited to such lands. The Alaska Territorial Legislature appropriated and made available to the Alaska Game Commission in the spring of 1925, \$10,000, for stocking such lands. Operations under this appropriation to date have consisted in placing beaver and muskrats on the Kodiak-Afognak Islands group. Protective work is receiving good support from Alaskans. Cooperative policing is carried on with the adjacent Canadian provinces of British Columbia and Yukon Territory. As a whole the future is bright for increasing the supply of Alaska wild life. Slides were shown of deer, moose, bear, mountain sheep, caribou, beaver, mink, marten, muskrat, rabbit, sea lion, ptarmigan, grouse, eagle, scenery, and miscellaneous subjects. (*Author's abstract.*)

EDGAR T. WHERRY, Bureau of Chemistry: (*Exploring for wild flowers in the Gulf States* (illustrated).)—The trip described was taken in company with Dr. J. K. SMALL of the New York Botanical Garden to obtain data as to distribution of native plants, especially in the south central states (Louisiana, Texas, Oklahoma, and Arkansas), in preparation for publishing a complete revision of Small's "Flora of the Southeastern United States." Transportation was by automobile, and 7,000 miles were covered in 7 weeks. The

route was from Cape Sable, Florida, around the Gulf coast to Brownsville, Texas, then to El Paso, Texas, and eastward by a more northern line through Oklahoma, Arkansas, northern Louisiana, and back to Florida. Although the limited time available made frequent stops impossible, many species were collected and data as to their habitat obtained. Particular attention was paid to *Iris*, and a considerable number of undescribed species were discovered; roots have been sent to the New York Botanical Garden and when the plants flower, they will be painted and described. New species in several other genera were also found, and many extensions of range established.

The speaker had taken photographs of many of the plants seen, using a 4 x 5 camera with only a low-priced lens, but with long bellows and swing-back. Commercial orthochromatic cut films were used throughout, and were highly satisfactory, even for yellow and red flowers, for which an orange ray-screen was employed. Color notes were taken in the field, and 75 lantern slides made from the negatives obtained, painted with transparent water-colors, were shown. (*Author's abstract.*)

692D MEETING

The 692d meeting was a joint meeting with the Audubon Society of the District of Columbia and was held April 10, 1926 at 8:00 p.m., in the auditorium of the National Museum, with President T. S. PALMER of the Audubon Society in the chair and 200 persons present. The program consisted of the following papers:

A. O. GROSS, Bowdoin College: *The threatened extinction of the heath hen on Martha's Vineyard* (illustrated).—In Colonial times the heath hen (*Tympanuchus cupido*) ranged from Maine to Carolina. By 1840 it had disappeared from the mainland of Massachusetts and Connecticut. In 1868 there were still a few on Long Island and in New Jersey, but since 1870 it has existed only on Martha's Vineyard. Brewster in 1890 estimated the number of birds at 150 to 200. In 1906 there were less than 100. By 1916 the number had increased to about 2,000. A great fire in the spring of 1916 destroyed many nests and much of the birds' natural cover, and during the next winter the number was reduced by hawks and other causes to about 150. In 1917 there were about 300, but in 1925 the number was reduced to about 25. The Federation of New England Clubs secured the services of a special warden, and by 1926 the number has increased to about 35. The speaker hopes that under the care of this warden the heath hen may be preserved from extinction. Views were shown of some of the birds and of the heath hen reservation.

A. O. GROSS: *The jungle life of Panama* (illustrated).—The speaker spent several months in 1925 studying the bird and animal life on Barro Colorado Island in the Canal Zone. He showed numerous views of the city of Panama and the Canal Zone and of its distinctive birds and animals. Most of the smaller birds lay only two eggs, in decided contrast with the birds of the temperate zone.

S. F. BLAKE, *Recording Secretary.*

ANTHROPOLOGICAL SOCIETY

597TH MEETING

The 597th meeting of the Society was held in the United States National Museum on April 20, 1926.

Program. Dr. WALTER HOUGH: *Fifty years of Pueblo Archeology.* Exploration during the past fifty years in the Pueblo region forms an interesting history. Veterans of the discovery of the cliff-dwellings in 1874-75 are still with us, W. J. JACKSON, who discovered and photographed, and W. H. HOLMES, who first sketched and pictured them in oils. As this work on the Southwest archeology was carried on by the U. S. Geological Survey and the Bureau of American Ethnology almost exclusively until recent years, it is observed that more than half of the investigators were members of the Anthropological Society of Washington.

In the period of reconnaissance beginning in 1869 the names of HOLMES, JACKSON, YARROW, POWELL, STEVENSON, BANDELIER, and CUSHING stand out prominently. Beginning in 1879 work in all the branches of anthropology was actively prosecuted by the Bureau of Ethnology. In 1886 the MINDELLEFFS studied the architecture of the ancient and modern pueblos over a wide region, furnishing invaluable data. Exploration in the sense of excavation of ruins began in the 80's. CUSHING carried on exploration work on a large scale in the lower Salt River Valley and also collected archeologica at Zuni. Historically, the first ruin explored was at St. George, Utah, in 1869-70 by EDWARD PALMER, a most indefatigable collector. The St. George specimens are in the National Museum and the Peabody Museum at Cambridge, Mass. In 1894 NORDENSKIÖLD published the results of his exploration of Mesa Verde cliff-dwellings. This work is a landmark. In the 90's Dr. J. WALTER FEWKES entered the field, exploring a ruin called Skyatki on the Hopi Reservation. Dr. FEWKES continued his researches for many years and is still active. In this period came HOUGH, HEWETT, MOOREHEAD, DORSEY, OWENS, PEPPER, HRDLICKA, PRUDDEN, and others.

The period of more intensive exploration presents the names of KIDDER, NELSON, MORRIS, JUDD, CUMMINGS, SPIER, GUERNSEY, JEANCON, sent out by different institutions. In this period methods depending on a classification of sherds, the presence or absence of pottery, stratification and superposition, have cast much light on the history of the ancient peoples of the southwest. We have here a good example of the normal development of research in the past 50 years. The order of culture in the ancient pueblos is now tentatively *basket maker*, *post-basket maker*, *pre-pueblo*, *pueblo*, and *recent*. Much is to be expected of the active and enthusiastic workers of the present in clearing up the problems of Pueblo archeology, and the best wishes of the Old Guard go with them.

The modern phase of pueblo exploration which was formerly impracticable in the vast field to be covered is seen in the National Geographic Society's work at Pueblo Bonito under the direction of NEIL M. JUDD, and Dr. A. V. KIDDER's work for Phillips Academy, Andover, Mass., at Pecos. It is seen that great financial resources are necessary to uncover and explore thoroughly one relatively large ruin. This, however, is the only way to elicit the further story of ancient Pueblo Indian life.

JOHN M. COOPER, *Secretary.*

SCIENTIFIC NOTES AND NEWS

Dr. A. S. HITCHCOCK attended the International Congress of Plant Sciences recently held at Ithaca, where he gave a paper by invitation and led the round-table discussion on nomenclature. He was appointed a member of the International Committee on Nomenclature.

Mr. T. A. SPRAGUE, of the Kew Herbarium, London, England, spent a week at the U. S. National Herbarium studying the *Dilleniaceae*, after attending the International Congress of Plant Sciences at Ithaca.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 16

OCTOBER 4, 1926

No. 16

CRYSTALLOGRAPHY.- *The optical properties of some sugars.*¹

GEORGE T. KEENAN, Bureau of Chemistry. (Communicated by
EDGAR T. WHERRY.)

The value of the optical properties for the identification of crystallized substances is now well recognized, and several systematic lists of properties in individual groups of compounds have been published. Thus far, however, there has been no comprehensive treatment of the commoner sugars. Some of the data here presented have been assembled from the crystallographic descriptions by Groth,² and some from the publication on the pentoses by Wherry.³ Through the cooperation of the Carbohydrate Laboratory of the Bureau of Chemistry, many of the crystalline sugars were made available. The study of the optical properties of these sugars was carried out by the immersion method as applied by crystallographers.

Sugars are insoluble in the only liquids commonly used in the immersion method. The liquids best suited for this study proved to be mixtures of mineral oil with $n = 1.49$ and monochloronaphthalene with $n = 1.64$ in such proportions that each liquid differed in n from the next by 0.005 or, in certain ranges, by a smaller amount. Their exact n values were determined on a refractometer; observations were made in yellow light, approximating that of the D-line, obtained by interposing a yellow glass or gelatine film between a source of white light and the microscope mirror.

The author desires to acknowledge the assistance of Mr. H. S. Paine and Dr. D. H. Brauns of the Carbohydrate Laboratory in furnishing the sugars for this study and of Dr. E. T. Wherry for suggestions in the preparation of the paper.

¹ Received Aug. 14, 1926.

² GROTH, P. *Chem. Krystallog.* 3: 450. Also 435 and 448. 1910.

³ WHERRY, EDGAR T. *Crystallography and optical properties of three aldopentoses.* *Journ. Amer. Chem. Soc.* 40: 1952. 1918.

1-ARABINOSE

In ordinary light.—Crystals rod-like, with prominent oblique terminations, the rods being often collected in stellate groups or twins.

Refractive indices.—(D). $n_\alpha = 1.551$, $n_\beta = 1.567$, $n_\gamma = 1.571$, $n_\gamma - n_\alpha = 0.020$, all ± 0.001 ; n_α is usually shown crosswise, and n_γ lengthwise.¹

Characters shown in parallel polarized light with crossed nicols.—Extinction apparently inclined, but angle small; double refraction rather strong, (0 020), the colors being mostly first order; elongation negative.

Characters shown in convergent polarized light with crossed nicols.—Only traces of negative biaxial figures with large axial angle (90° ?) obtainable.

Distinctive characters.—The minimum and maximum refractive indices ($n_\alpha = 1.551$, $n_\gamma = 1.571$) are both of value in identifying the substance.

FRUCTOSE

In ordinary light.—Consists of thin rods.

Refractive indices. (D).— $n_\alpha = 1.558$, $n_\beta = \text{indet.}$, $n_\gamma = 1.561$, both ± 0.003 , n_α occurs lengthwise and n_γ crosswise; both easily found.

Characters shown in parallel polarized light with crossed nicols.—Double refraction very weak (0.003), mostly first order colors being shown; extinction parallel; elongation negative.

Characters shown in convergent polarized light with crossed nicols.—None.

Distinctive characters.—The minimum and maximum refractive index values ($n_\alpha = 1.558$, $n_\gamma = 1.561$) are both readily found and significant for the substance. The weak double refraction differentiates this from all the other sugars studied.

D-GLUCOSE HYDRATE

In ordinary light.—Consists of six-sided plates.

Refractive indices. (D).— $n_\alpha = 1.521$, $n_\beta = \text{indet.}$, $n_\gamma = 1.549$, both ± 0.002 .

Characters shown in parallel polarized light with crossed nicols.—Double refraction moderate, $n_\beta - n_\alpha = 0.018$; colors 1st or 2nd order.

Characters shown in convergent polarized light with crossed nicols.—The plates all extinguish sharply, indicating that β is more or less perpendicular to their broad face so that interference figures could not be expected; extinction parallel; elongation negative.

Distinctive characters.— $n_\alpha = 1.521$ and $n_\gamma = 1.549$ both occur frequently enough to be of value for determinative purposes.

α -LACTOSE HYDRATE

In ordinary light.—The α -form or commonly recognized lactose hydrate is seen to consist of characteristic tomahawk-shaped crystals.

Refractive indices. (D).— $n_\alpha = 1.517$, $n_\beta = 1.542$, $n_\gamma = 1.550$, all ± 0.005 .⁴

Characters shown in parallel polarized light with crossed nicols.—Second and third order colors evident, double refraction fairly strong (0.033); $Bx \wedge c = 10^\circ$, $\wedge a = 99^\circ$.

Characters shown in convergent polarized light with crossed nicols.—Optic sign —; $2E = 33\frac{1}{2}^\circ$; figures rare.

Distinctive characters.—The characteristic shape of the crystals and the minimum and maximum indices of refraction are useful in identifying the substance.

LYXOSE

In ordinary light.—The material consists of six-sided grains, but little elongated in any direction.

Refractive indices. (D).— $n_\alpha = 1.532$, $n_\beta = 1.541$, $n_\gamma = 1.549$, $n_\gamma - n_\alpha = 0.017$, all ± 0.001 ; n_α usually shown in one direction, and n_γ in the other.²

Characters shown in parallel polarized light with crossed nicols.—Extinction inclined, the angle, being, however, very small; double refraction moderate (0.017), colors being mostly first or second order.

Characters shown in convergent polarized light with crossed nicols.—Interference figures rarely seen, but occasionally part of a negative figure with very large axial angle is obtained.

Distinctive characters.—The maximum refractive index value, $n_\gamma = 1.549$, is readily found and is diagnostic for the substance, although the other value, $n_\alpha = 1.532$, may also be used.

d-MANNOSE

In ordinary light.—The material consists of small, six-sided plates and rods.

Refractive indices. (D).— $n_\alpha = 1.529$ crosswise; $n_\beta = 1.536$, lengthwise; $n_\gamma = 1.563$ crosswise; all ± 0.002 .

⁴ WHERRY, EDGAR T. JOURN. Agric. Research 21: 793. 1921.

Characters shown in parallel polarized light with crossed nicols.—Double refraction fairly strong (0.034); extinction varying from parallel to inclined; elongation $\pm$.

Characters shown in convergent polarized light with crossed nicols.—Partial interference figures occasionally shown with plates inclined to an optic axis.

Distinctive characters.—The most significant refractive index value for this substance is $n_\beta = 1.536$ which occurs frequently lengthwise on six-sided rods.

d-MELIBIOSE

In ordinary light.—Habit rod-like, quadrilateral forms also being common.

Refractive indices. (D).— $n_\alpha = 1.526$ shown lengthwise; $n_\beta = 1.541$ shown crosswise; $n_\gamma = 1.560$ common, and occurring lengthwise; all ± 0.002 .

Characters shown in parallel polarized light with crossed nicols.—Polarization colors brilliant, 2-3 order; double refraction fairly strong (0.034); extinction parallel; elongation positive.

Characters shown in convergent polarized light with crossed nicols.—Biaxial interference figures rare; 2E appears to be large.

Distinctive characters.—The most characteristic optical constant for determinative purposes is the value of the maximum index, $n_\gamma = 1.560$ which occurs frequently on elongated forms lengthwise.

RAFFINOSE

In ordinary light.—The material consists of flaky rods and needles.

Refractive indices. (D).— $n_\alpha = 1.522$ lengthwise and common; $n_\beta = \text{indet.}$; $n_\gamma = 1.537$ crosswise; both ± 0.002 .

Characters shown in parallel polarized light with crossed nicols.—Double refraction moderate (0.015); extinction parallel; elongation negative.

Characters shown in convergent polarized light with crossed nicols.—None.

Distinctive characters.—The moderate double refraction and the refractive index shown lengthwise on rods and needles ($n_\alpha = 1.522$) are characteristic of this substance and should prove of value for determinative purposes.

RHAMNOSE MONOHYDRATE

In ordinary light.—The material consists of irregular fragments.

Refractive indices. (D).— $n_\alpha = 1.523$, $n_\beta = 1.531$, $n_\gamma = 1.534$.¹

Characters shown in parallel polarized light with crossed nicols.—Double refraction moderate, (0.011).

Characters shown in convergent polarized light with crossed nicols.—Biaxial interference figures common, particularly grains perpendicular to an optic axis; optic sign —, $2V = 95^{\circ}51'$.

Distinctive characters.—The frequency with which fragments show one optic axis up in the interference figure, also the minimum and maximum refractive index values ($n_{\alpha} = 1.523$ and $n_{\gamma} = 1.534$), are useful for determinative purposes.

d-RIBOSE

In ordinary light The material consists largely of rods and occasionally irregular fragments.

Refractive indices. (D).— $n_{\alpha} = 1.533$ shown lengthwise, $n_{\beta} = 1.549$ shown crosswise, $n_{\gamma} = 1.570$ shown crosswise, all ± 0.002 .

Characters shown in parallel polarized light with crossed nicols.—Double refraction strong (0.037); extinction parallel; elongation negative.

Characters shown in convergent polarized light with crossed nicols.—No interference figures shown.

Distinctive characters.—The minimum refractive index value ($n_{\alpha} = 1.533$) and the maximum value ($n_{\gamma} = 1.570$) are both readily obtained, the former occurring lengthwise and the latter crosswise.

SUCROSE

In ordinary light.—The material consists of irregular fragments without any definite habit.

Refractive indices. (D).— $n_{\alpha} = 1.540$; $n_{\beta} = 1.567$, $n_{\gamma} = 1.572$.

Characters shown in parallel polarized light with crossed nicols.—Double refraction fairly strong (0.032); second and third order colors shown.

Characters shown in convergent polarized light with crossed nicols.—Interference figures common, grains perpendicular to an optic axis being readily located; $2V = 48^{\circ}0'$; ax.pl.b (010); $X \wedge c = 67^{\circ}$ in obtuse angle β ; optic sign —.

Distinctive characters.— $n_{\beta} = 1.567$ occurs very frequently and is considered significant for determinative purposes. The readiness with which interference figures are found is also characteristic of the substance.

TREHALOSE

In ordinary light.—The material occurs in the form of rods with oblique terminations.

Refractive indices. (D).— $n_\alpha = 1.528$ shown crosswise and easily found; $n_\beta = \text{indet.}$; $n_\gamma = 1.533$ shown lengthwise; both ± 0.002 .

Characters shown in parallel polarized light with crossed nicols.—Colors gray; double refraction weak (0.005); extinction parallel; elongation positive.

Characters shown in convergent polarized light with crossed nicols.—No interference figures obtainable.

Distinctive characters.—The weak double refraction and the refractive index shown crosswise are characteristic of this substance and should be of value in determinative work.

d-XYLOSE

In ordinary light.—The material consists of irregular fragments.

Refractive indices. (D).— $n_\alpha = 1.517$, $n_\beta = 1.544$, $n_\gamma = 1.546$, all ± 0.001 .¹ Fragments extinguishing in a hazy, indefinite manner (with crossed nicols) and showing (in convergent light) interference figures characteristic of grains perpendicular to acute bisectrix show $n_\beta = 1.544$ in one extinction position and $n_\gamma = 1.546$ in the other.

Characters shown in parallel polarized light with crossed nicols.—Polarization colors brilliant, two or three distinct marginal color bands showing on many of the fragments; double refraction fairly strong (0.029).

Characters shown in convergent polarized light with crossed nicols.—Biaxial interference figures common, many grains showing sections perpendicular to the acute bisectrix; $2E = 36^\circ$ (approx.); optic sign —.

Distinctive characters.—The minimum and maximum refractive index values are readily found in this substance and can be used in identifying it optically.

DETERMINATIVE TABLE FOR THE SUGARS

Immerse crystalline material in the liquids of refractive indices shown in the left-hand column, made by mixing mineral oil and monochloronaphthalene. Examine under the microscope with polarizer in place and diaphragm partially closed, trying one liquid after another until the outlines of the fragments disappear when in one position in the field. Confirm identity of the material by the data in the central column, and obtain the name of the sugar in the right-hand column.

TABLE 1.—DESCRIPTION OF CRYSTALS AND CONFIRMATORY DATA

<i>Index</i>		<i>Sugar</i>
1.517	Tomahawk-shaped crystals are significant for this sugar. Confirm by immersion in liquid 1.550	α -Lactose hydrate
1.521	Material consists of six-sided plates, all extinguishing sharply, precluding interference figures. Confirm by immersing in liquid 1.549	d-Glucose hydrate
1.522	Material consists largely of rods and needles, this index being shown lengthwise. Confirm by immersing in liquid 1.537, which matches γ shown frequently crosswise	Raffinose
1.528	Rods with oblique terminations. This index is shown crosswise. Confirm by immersing in liquid 1.533, which matches γ shown frequently lengthwise on rods	Trehalose
1.534	Irregular fragments. Biaxial interference figures common. Confirm by immersing in liquid 1.523 which matches α	Rhamnose hydrate
1.536	Six-sided plates and rods. Confirm by immersing in liquid 1.563, which matches γ , shown frequently crosswise on rods	d-Mannose
1.546	Irregular fragments. Confirm by immersing in liquid 1.544, which matches β , shown frequently on fragments extinguishing in a hazy, indefinite manner	d-Xylose
1.549	Six-sided grains but little elongated in any direction. Confirm by immersing in liquid 1.532, which matches γ , and shown frequently	Lyxose
1.558	Thin, colorless rods, this index occurs lengthwise. Confirm by immersing in liquid 1.561, which matches γ , shown frequently crosswise on rods.	Fructose
1.560	Rod-like and some quadrilateral forms, this index occurs lengthwise on rods. Confirm by immersing in liquid 1.541, which matches β shown frequently on rods crosswise	d-Melibiose
1.567	Irregular fragments; ease with which interference figures are found significant for this sugar. Confirm by immersing in liquid 1.572, which matches γ	Sucrose
1.570	Consists largely of rods, this index is shown crosswise on rods. Confirm by immersing in liquid 1.533, which matches α , and is shown frequently on rods lengthwise	d-Ribose
1.571	Rod-like, with prominent oblique terminations; this index occurs lengthwise on rods. Confirm by immersing in liquid 1.551, which matches α , shown frequently crosswise on rods.	d-Arabinose

TABLE 2.—OPTICAL CHARACTERS OF SUGARS DESCRIBED

	FRUCTOS	d-GLUCOSE HYDRATE	d-GLUCOSE HYDRATE	LYXOS	d-MAU- ROSE	d-MELIB- IOSE	RAPIFIOSE	MSAMMON HYDRATE	d-ARABIN	ERYTHROSE	TRIMA- ROSE	d-XYL/OS
Habit	rods	plates	plates	grains	plates	rods	rods	plates	rods	plates	prisms	plates
Indices:												
n_D	1 558	1 521	1 517	1 532	1 529	1 526	1 522	1 523	1 533	1 540	1 528	1 517
n_D	undet	undet	1 542	1 541	1 536	1 541	undet	1 531	1 549	1 567	undet	1 544
n_D	1 561	1 549	1 550	1 549	1 563	1 560	1 537	1 534	1 570	1 572	1 533	1 546
n_D	0 003	0 018	0 033	0 017	0 034	0 034	0 015	0 011	0 037	0 032	0 005	0 019
Distinctive	1 571	1 521	1 550	1 512	1 529	1 526	1 522	1 534	1 570	1 567	1 528	1 546
Colors ..	low 1	1-2	2-3	1-2	2-3	2-3	1-2	1-2	2-3	2-3	1	2-3
Extinction.	st	st	incl	incl	st in	st	st	incl	st	incl	st	incl
Elongation	—	—	±	undet	±	±	—	undet	—	undet	+	undet.
Figures ..	0	0	rare	rare	rare	rare	0	freq	freq	freq	0	freq
2E	90°	undet	333°	undet	undet	large	undet	95°51'	undet	79°7'	undet.	33°
Sign	undet	undet	—	undet	undet	undet	undet	—	undet	—	undet	—

ZOOLOGY.—*Mammals of the vicinity of Washington.*¹ VERNON BAILEY, Biological Survey, U. S. Department of Agriculture.

Two hundred years ago the country now occupied by Washington and the District of Columbia was real wilderness, teeming with game animals, large and small. There were buffaloes, elk, deer, bears, panthers, wolves, beavers, and martens, which have since disappeared before the advance of civilization, but most of the smaller quadrupeds of that day are still to be found here in more or less reduced abundance. Some species, however, are probably just as numerous, and others may be more so than in the days of the Indian and the buffalo.

Unlike the birds most of the mammals are rather plain in appearance or highly protective in their colors and not easily seen when they sit still, and further to escape our notice they move about mostly at night in search of food or in carrying on their family affairs, and then sleep hidden away in their nests during the daylight hours. For these reasons the study of mammals is not so easy and generally attractive to beginners as that of birds, insects, or plants, but the very difficulty of finding their haunts and learning their habits renders the study especially fascinating to those who know how to go about it. One of the chief interests lies in our surprises as we discover in the small timid creatures intelligence and feelings akin to our own, for we too are mammals with well-developed brains, minds, and psychic senses, generally a little ahead of the rest of our class.

Here in the District of Columbia we have an excellent opportunity for the study of our native animals, although the rabbits, woodchucks, squirrels, and chipmunks are the only diurnal species. Many of the others can be watched during the evening or morning twilight hours, and still others may be caught in cage traps or bottle traps and kept in captivity long enough for careful study of their habits, intelligence, and dispositions. If given good care and quarters with comfortable, sanitary, and attractive cages, most of the small animals enjoy their captivity and some will become sufficiently gentle to be natural and easily handled. Others may be watched and partially tamed while entirely free in their native haunts.

The gray squirrels in our parks and yards readily respond to human attentions and kindness. Quick in reaction to a threat from man or dog or cat and in taking refuge in treetops, they are just as quick to recognize a friendly look or gesture and in coming boldly up to receive

¹ Radio talk, May 22, 1926, under the auspices of the National Zoological Park, arranged by Austin H. Clark. Received Aug. 4, 1926.

food from the extended hand. But we are not always consistent in our treatment of our squirrel friends, for at times we feed them lavishly and again, when they especially need food and water, we forget about them and leave them to suffer or hunt for new homes. They need water every day and suffer oftener with thirst than with hunger. We could also add greatly to their comfort by occasionally puffing flea powder and sulphur into their nests to kill the parasites that torment them. At times these are so troublesome that the squirrels are forced to leave home and build fresh nests of leaves in the branches of the treetops.

The big yellow fox squirrels and the bright little red squirrels may be found in the neighboring woods, but have not yet gained enough confidence in man to visit our yards and parks.

The little striped chipmunks are occasionally seen on the edge of the woods or in Rock Creek Park, scampering for the nearest holes in the ground or to hollow stumps or logs, where they can feel safe. They have good reason to be timid and nervous, for stray cats leave few of them to be seen by anyone. Nevertheless they usually respond to soft words and proffered food. Rolled oats and nuts are the most enticing bait with which to win their confidence, and with skill and patience you can soon have them eating out of your hand. In this climate they are generally out on warm days all winter but in the North they are one of the seven sleepers who spend the winter in deep hibernation.

The big fat woodchucks, or groundhogs, also of the squirrel family, are another of the seven sleepers and may be found up the Potomac half way to Great Falls. Often they are seen sitting on the rocks sunning themselves on summer mornings, or out in clover fields in autumn, getting fat as fast as they can for their long winter sleep. In the North they generally remain curled up in their underground nests from October to April, but in the mild climate of Washington they often wake up during a warm wave and not infrequently may see their own shadows on the fateful Groundhog Day of February second. Whether they see their shadows or not they generally go back and sleep through several weeks more of cold winter weather. As a matter of fact they usually sleep most of the time until the green grass and clover come up in spring to supply their food and take the place of last year's accumulation of fat, which has carried them through the winter. Because they eat his clover the farmer generally considers them his enemies and makes war upon them with dogs, guns, and traps, so they are among the most shy and timid of our wild animals, but they are often tamed and make interesting pets.

The little flying squirrels with soft coats of fur, big eyes, spreading tails, and folded winglike membranes along the sides of the body are beautiful and gentle little animals, but so owl-like in their nocturnal habits that they are rarely seen alive. They sleep all day in some hollow tree, old woodpecker hole, or a soft bark nest in the top branches of a juniper tree, and if one knows how and where to look for them, they are sometimes found in the very edges of Washington. If you pound on the tree with a stone or an ax you may see a little gray nose and beady eyes appear in the doorway above, and if you pound still harder you may see the wings unfold and carry the little animal, gliding rapidly on the air, to some other tree 20 to 50 feet distant. It is not real flying, however graceful and wonderful it may seem, for the animal always alights lower down than where it started, and only by running up each tree trunk and soaring to another point lower down can it progress rapidly through the forest. Flying squirrels are easily tamed and make interesting and lovable pets if you have the right kind of place for them. At large, in the house, they are apt to do some mischief by making their nests in curtains, cutting up papers and clothing for nest material, or knocking things off the shelves and bookcases.

Cottontail rabbits are often seen in the District of Columbia, where they are protected from hunting, and they would be much more common if it were not for stray cats and dogs that catch many of them before they grow up. If given a reasonable degree of protection they soon multiply and become common up to the edges of the city, in the parks, and even in our dooryards. In many states cottontails are considered the most valuable game animal because they are so abundant that they afford hunting for more people than all the other game. For my part I would rather see them around than shoot them, though when they get too numerous, I see no harm in rabbit pies. Too many rabbits might destroy all our bushes and young trees.

Speaking of destructive animals, the brown rat, or wharf rat, is the most destructive and offensive animal we have, not only in the city and in any houses or buildings where they can gain an entrance, but also out in the fields wherever there is grain or food to their liking. They are not only filthy and destructive but dangerous as well, for they carry disease and have been among the chief distributors of bubonic plague. With modern methods of destroying rats and keeping them from obtaining food they are now less destructive and dangerous than at any time since they were brought to this country from Europe in the early colonial days.

We have also a native animal called a wood rat, or pack rat, very different from the Old World rats, a large-eared, soft-furred, bright and pretty little inhabitant of the woods and rocky cliffs. A few may be found along the rocky banks of the Potomac near Great Falls, but they are so scarce, so shy and so strictly nocturnal that they are rarely seen unless captured for study or for specimens.

Our fur-bearing animals are represented by a few red and gray foxes, raccoons, opossums, otters, minks, weasels, skunks, and muskrats, all rather scarce and rarely seen except by trappers.

The mere mention of mice will no doubt cause a shudder, just because everybody knows the disagreeable, smelly pest of our pantries and cellars--the house mouse, which was also introduced from the Old World.

But we have many small native animals of mouse size in our fields, meadows, and forests without any of the disagreeable traits of the house mice, and each of the half dozen different kinds is as interesting in its habits and means of making a living as any of our larger animals. Some of the small animals are useful to man, while some are of no economic importance; others can do great damage to our crops and fruit trees if we do not watch out. The meadow mice and pine mice, or apple mice, are the most dangerous species, often destroying crops and killing fruit trees on a large scale, but they are not difficult to control. The little harvest mice and the deer mice are bright and pretty and practically harmless, while the long-tailed jumping mice are entirely harmless and especially interesting in their habits. Like the woodchucks they have solved the fuel problem by going to sleep in warm nests underground when the nights get cold in October, and waking up when the flowers begin to bloom in the spring, some five months later. We are still ignorant as to whether the time they spend in sleep is deducted from their allotted span of life, or whether added to it, and I am keeping several of them in comfortable captivity to determine this point before recommending hibernation to any of my friends.

Another group of small animals, including the insect eaters, the moles and shrews, is well represented here. The common mole is plentiful and the star-nosed mole is rare, but both are animals highly useful to man and very interesting from their burrowing habits and their ravenous appetites. They feed almost entirely on earthworms, cutworms, and other small insect and animal life found under the surface of the ground.

The shrews of about four different species have much the same food

habits as the moles, but being smaller take other sets of insects and smaller animal life. They vary in size from the velvety, short-tailed shrew, about the size of a mouse, down to the tiny least shrew, the smallest mammal in America, if not in the world. Each species, however, fills its place in the animal economy of our country, and in preserving a wholesome balance of nature.

Bats are well represented about Washington by at least ten species, and of about half of these there is an abundance of individuals. They range from the great hoary bat, the large brown bat, the silvery-haired and red bats down to the little brown bat, the least brown bat, and the little pipistrelle. Anyone can see them flitting about the houses and trees in town or out in the woods on warm evenings in summer, and usually can recognize some of them by different sizes and colors before the twilight is too far advanced. To many the mention of bats brings up pictures of darkness and mystery, and vermin and hooked claws entangled in ladies' hair, and a general feeling of terror and disgust, all products of ignorance and imagination. Our bats are really highly specialized and intelligent mammals. They are clean in habits and usually free from parasites and have never been known to get in anyone's hair or to bite or hurt anyone unless abused. If handled gently they soon become quite tame and make interesting house pets, learning to come for food and water at regular times and quickly ridding the house of moths and night-flying insects.

In many cases we find a practical advantage in knowing our friends and foes in the animal world, but in any case we understand ourselves better by knowing more of what we have been taught to call the lower animals.

ZOOLOGY.—*A new toad from China.*¹ LEONHARD STEJNEGER, United States National Museum.

Among the collections brought home by Mr. F. R. Wulsin, leader of the National Geographic Society's Expedition to Kokonor in 1923, there is a large series of an undescribed species of toad. It was collected during his stay from August 24 to 31 at Choni, on the Tao River, about 120 miles south of Lanchow, Kansu, China, consequently on the north slope of the Min range, which here forms the boundary between the provinces of Kansu and Szechwan. Rev. D. C. Graham, during his trip to Sungpan in 1924 obtained a number of specimens at the latter place, consequently on the south slope of the same range.

¹ Received Aug. 21, 1926.

Whether its habitat is restricted to this mountain system remains to be seen.

Bufo minshanicus, sp. nov.

Diagnosis.—Top of head without bony crests, except a faint one on canthus rostralis; first finger longer than second; toes webbed one half or more; sub-articular tubercles double; tarsal fold more or less distinct; tympanum distinct, less than $\frac{1}{2}$ diameter of eye; top of head with large rounded warts; upper side of tibia with large warts, more or less confluent; a large oblong gland on outer side of tarsus.

Type.—U. S. National Museum No. 68567.

Type-locality.—Choni, on Tao River, Kansu, China.

Total length of type, an adult female, 78 mm.

Remarks.—This species is easily recognized among Chinese toads by the large globular tubercles on top of the head, especially a semicircle of three or four large ones marking the inner edge of the upper eyelid. The canthal ridge is also generally covered with one or more large warts. On the upper side of tibia there is one or more conspicuously large glands.

ZOOLOGY.—*A new Pelobatid batrachian from Borneo.*¹ DORIS M. COCHRAN, United States National Museum. (Communicated by A. WETMORE.)

In the splendid collection of amphibians from Borneo sent to the United States National Museum by Dr. W. L. Abbott some years ago, there is a Pelobatid toad belonging to the genus *Megophrys*, which has not been described. I take great pleasure in naming it after the collector, whose untiring efforts have resulted in a vast enrichment of our scientific knowledge in nearly every branch of biology.

Megophrys abbotti, new species

Diagnosis.—Profile of snout obliquely truncate, strongly projecting beyond lower jaw; canthus rostralis angular and loreal region oblique; head one and one-fifth as broad as long; tympanum distinct; tibio-tarsal articulation not reaching beyond eye; tibia two and one-half times in length from snout to vent; toes with a slight rudiment of web; vomerine teeth none; tympanum half the diameter of the eye and greater than its distance from the eye; nostril much nearer end of snout than eye.

Type.—U. S. National Museum no. 39097, collected at Balik Papan Bay, Eastern Borneo, February 6, 1909, by Dr. W. L. Abbott.

Description.—Tongue nicked behind; head moderate, one and one-fifth times as broad as long; pupil vertical; snout obliquely truncate in profile, projecting beyond the lower jaw, longer than the eye; canthus rostralis very sharp; loreal region vertical, slightly concave; nostril situated at extreme end of canthus rostralis and much nearer to tip of snout than to eye; interorbital

¹ Published by permission of the Secretary of the Smithsonian Institution. Received Aug. 14, 1926.

space flat, one and one-half times as broad as the upper eyelid; tympanum very distinct, half the diameter of the eye, and greater than its distance from the eye; fingers with very feebly swollen tips, first and second equal, about two-thirds the length of the third; subarticular tubercles absent; two large carpal tubercles, the inner somewhat the more pronounced; a small and inconspicuous inner metatarsal tubercle; no outer metatarsal tubercle; toes slender, with feebly swollen tips, slightly webbed, the web fringing the first two toes nearly to their tips; a small dermal ridge beneath the fourth toe; tibio-tarsal articulation reaching the eye; tibia two-fifths the distance from snout to vent; foot shorter than tibia. Skin on top of head perfectly smooth, on back very minutely "shagreened," on eyelids and sides of head and body distinctly dotted with glandules, on lower surfaces perfectly smooth. A strong glandular ridge beginning at the nostrils and extending along the canthus rostralis, continuing again on the posterior corner of the eyelid, extending above the tympanum and beyond it almost to the shoulder; a flattened wart on each side of the breast behind the insertion of the fore limb; no warts on the chin.

Coloration yellowish brown above, with no markings excepting a dark patch beneath the canthus rostralis, a small dark spot on the posterior corner of the eyelid, and another on the tympanum; under surface yellowish white, the chin and throat tan. The type is unique.

Dimensions

	mm.		mm.
Snout to vent	54	Diameter of tympanum	4.5
Length of head to occiput	20	Distance between eye and	
Width of head	25	tympanum	3
Extreme tip of snout to eye	10	Hand	14
Diameter of eye	9	Tibia	22
Interorbital width	8	Foot	19

From the five species of *Megophrys* already known from Borneo and listed in Dr. Van Kampen's excellent work on the Amphibia of the Indo-Australian Archipelago (1923), this species can be easily distinguished. It could never be confused with *M. montana*, which has a pointed eyelid, nor with *M. nasuta*, possessing a pointed snout. *Megophrys gracilis*, also of Borneo, is a very long-legged toad, unlike *M. abbotti*; *M. baliuensis* has a head twice as broad as long, differing from the new species which has a head only one and one-fifth times as broad as long. From *M. hasselti*, the only remaining described species from Borneo, *M. abbotti* differs in possessing a very distinct tympanum, a sharply sloping and truncated snout, in having the nostrils situated at the extreme end of the upper surface of the snout, and in coloration.

In using the key contained in Boulenger's "Revision of the Oriental Pelobatid Batrachians (Genus *Megalophrys*)," the new species falls nearest to the Chinese *Megalophrys boettgeri*. But *M. boettgeri* has the tongue entire; the nostrils are equally distant from eye and from the end of the snout; the carpal tubercles are indistinct or absent; there are two warts on the chin; and finally, there are symmetrical blackish markings on the body. None of these characteristics are found in *M. abbotti*.

ENTOMOLOGY.—*New neotropical myrmecophiles.*¹ WILLIAM M. MANN, U. S. National Museum, Washington, D. C. (Communicated by S. A. ROHWER.)

Descriptions of the following new myrmecophilous beetles have been prepared for some time, and duplicate specimens of some of the

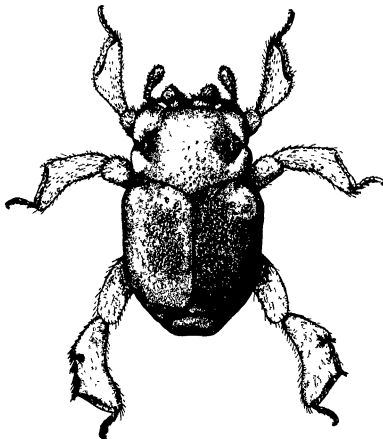


FIG. 1.—*Terapus mexicanus*

species have been sent to various correspondents. With the exception of the new species of *Terapus*, all of the myrmecophiles described in this paper are guests of various species of Army Ants.

***Terapus mexicanus*, new species**

Length 2 mm.

Brownish red, shining. Head sparsely, coarsely and irregularly punctate, and with short and fine erect hairs, clypeus and labrum smooth, front rather

¹ Received Aug. 25, 1926.

strongly concave and at middle with an impressed line extending to base of labrum; sides in front of eyes thickly margined, the margins diagonal above and extending forward as very fine carinae bordering the median impressed line, clypeus transversely concave. Pronotum with sparse irregular punctures, coarsest along the basal border, transverse, broadest behind, anterior border broadly emarginate at middle, anterior corners rounded, posterior corners broadly angulate, sides bilobed, the anterior lobe the longest of the two and the inner surface of both impressed, bordering a nearly flat triangular area in the middle of which is a rounded tubercle bearing a thin brush of yellow trichomes, median surface evenly convex. Elytra longer than broad, humeri gibbous, basal margin with several short, shallow impressions, surface with abundant elongate punctures, coarser than on pronotum. Propygidium transversely hexagonal, divided at middle by a bi-arcuate line, the upper surface flat, the lower surface roundly elevated at sides and concave at middle, surface very sparsely punctate. Pygidium a little broader than long, sparsely and finely punctate. Keel of prosternum as broad in front as behind, sides very feebly arcuate, nearly parallel, obtusely margined, the margins rounding and converging in front becoming almost obsolete, at middle posterior border broadly emarginate, surface finely and densely punctate and distinctly concave, a feeble transverse impression at base of lobe, which is finely punctate and shining, and, at anterior border, entire. Mesometasternum without dividing line, anterior border and sides with a fine margin, the anterior border biconcave, narrowly arcuate at middle, sides nearly straight. Legs broad, anterior femora stout, dorsal edge straight, ventral concave, tibiae broadly triangular, the basal half of outer border arcuate, apical half nearly straight, with a few very small widely separated spines, middle femora longer, tibiae elongate triangular, the basal edge feebly concave, longer than the apical, which is more concave and separated from it by an angle, posterior femora broad, rather compressed, with a strong transverse truncated lobe at base of dorsal border, ventral border concave at middle, rounded at base, tibiae broad and flattened, lower border concave at middle, upper border with the basal portion nearly two times as long as the apical, projecting and rounded at middle, separated from the anterior edge by an angle.

Type locality -Mexico, San Diego Cocula, Jalisco, Guadalajara

Host -*Pheidole kingi* Pergande

Type and paratypes -Cat No 29051 U S N M

Described from five specimens (one type) taken by the writer with host ant, which nests in populous colonies common on moist slopes

The legs, the elytra, the sculpture and color are entirely different from the other species of *Terapsus* to which I assign this species on account of the structure of the head and thorax. It has no close relationship with *T. murinechti*.

The pilosity is fine and very short above, equally fine but longer on the legs. There is a distinct though thin line of golden trichomes on the apical half of the upper edge of the basal part of the posterior tibiae.

Ecitophya rapaxae, new species

Length 6 mm

Opaque, dark brown to black, apical half of gaster, ventral surface of thorax, the coxae and trochanters lighter. Moderately fine and very dense punctation on head, body and appendages, elytra also finely tuberculate. Hairs coarse, erect, mainly black, but some with brownish reflections.

Head a little longer than pronotum, broadest just posterior to eyes from where the sides converge to the straight posterior border which is less than one-half as broad as the front between the eyes, vertex convex, front behind eyes with longitudinal impression at middle. Clypeus very strongly carinate at middle for two-thirds its length, anterior margin nearly straight. Eyes convex. Basal antennal joint two times as thick and two-thirds as long as the third, second joint about as long as broad, third joint longer than the fourth and fifth together, joints 3 to 9 nearly three times as long as broad, penultimate joint as long as the terminal, which is obliquely connate at tip. Pronotum only slightly broader than head including eyes, broadest behind middle, anterior angles and border broadly rounded, sides, posterior to middle feebly concave and divergent, posterior angles narrowly rounded, hind margin broadly convex, disc at middle narrowly and strongly impressed longitudinally, the impression somewhat broadened anteriorly, sides broadly and shallowly concave. Elytra broader than pronotum and much longer than broad, humeri broadly and posterior angles narrowly rounded, sides nearly straight, posterior border emarginate. Abdomen but little broader than elytra and shorter than head and thorax together. Legs very long and slender, with the posterior basitarsi nearly as long as the remaining joints together.

Type locality—Cachuela Esperanza, Rio Beni, Bolivia

Type—Cat No 29052 U S N M

Host—*Ecton rapax* Smith

A single specimen found by the writer in a file of the ants

This species is closest to *Ectophya simulans* Wasm., but distinct in the structure of the head, which is comparatively broad in front and strongly narrowed behind, its more convex eyes, more elongate elytra and coarser punctuation.

Ectomorpha melanotica, new species

Length 3.75 mm

Opaque black, appendages dark fuscous, evenly cribrate-punctate, more finely and shallowly on abdomen.

Hairs erect, black, long and finely tipped, moderately abundant, shorter and stiffer, semi-erect and more abundant on appendages.

Head more than twice as long as broad and a little broader behind than in front, sides feebly convex, front shallowly impressed at middle between eyes, vertical region feebly convex. Clypeus convex, anterior border broadly emarginate. Antennae long, thickened apically, the basal joint thick and convex at sides, shorter than joints 2 and 3 together, second joint a little more than half as long as the third and as long as the fourth, joints 4-10 gradually increasing in length and thickness and all distinctly longer than broad, the terminal one and one-third times as long as the penultimate and slightly narrower, slightly arcuate, narrowed and rounded apically. Pronotum a little shorter than in *E. arachnoides*, the median longitudinal impression strong, the lateral depressions very feeble. Elytra together a little broader than their length at suture, anterior and posterior corners broadly rounded, sides nearly straight, posterior border rather strongly emarginate at middle. Abdomen convex, elongate, as broad in front as behind, sides slightly arcuate.

Type locality—Mixco, Guatemala.

Host—*Ecton burchelli* var. *infumatum* Wheeler

Type.—Cat. No. 29053 U. S. N. M.

Described from a unique specimen, collected by the writer as the result of an hour's watch of an army of the ants.

This is distinct from *Ectomorpha arachnoides* Wasm. in having a shorter, broader head, more narrowly compressed between the eyes, and in its more slender antennal joints. The impressions on the sides of pronotum are more feeble than in *E. arachnoides*.

***Mimeciton antennatus*, new species**

Length 2.10 mm.

Yellowish brown, abdomen darker; subopaque, finely rugulose-punctulate, more finely and shallowly on the abdomen, which is moderately shining. Pile and pubescence very fine and silky, yellow in color, moderately abundant on head, body and appendages.

Head from the front, quadrate, about one and two-thirds times as long as broad, sides and posterior border straight, cheeks swollen, front between the antennal foveae strongly elevated and subcarinate, triangular in front and continuous with clypeus, the surface of which is flattened and the anterior border truncate; outer border of antennal foveae strongly margined. Mandibles thick basally, sharply pointed at tips. Antennae long and rather stout, their scapes longer than the head, of nearly uniform thickness and slightly arcuate; second joint broad, somewhat compressed and curved, longer than joints 3-4-5 together; joint 3 transverse, joints 4 to 9 gradually increasing in length and thickness, those anterior a little longer than broad; terminal joint longer than the preceding two together, shallowly constricted in front of middle, rounded at tip. Pronotum about two times as long as broad, broadest and with sides rounded in front, impressed shallowly and transversely near middle. Elytra without indication of suture, longer than broad, posterior border deeply emarginate, with the sides extending as vertical, rather thick lamellae, projecting and obtuse at tips and entirely concealing from the side the short abdominal peduncle. Abdomen very convex, strongly incrassate behind, shortly and narrowly pedunculate in front. Legs long and slender; joints of posterior tarsi very long.

Type locality.—Tena, Ecuador.

Host.—*Eciton (Labidus) praedator* F. Smith.

Type and paratypes.—Cat. No. 29054 U. S. N. M.

Described from five specimens (one type) taken by F. X. Williams, Feb. 24, 1923, in marching files of the host ant.

This species differs from *Mimeciton pulex* Wasm. and *Mimeciton sikani* Wasm., both of which also live with *Eciton praedator*, in being more opaque, in its shorter and broader head with the front more elevated between the antennal insertions, and in the form of the second antennal joint. This is peculiar being narrow basally, clavate anteriorly and broader than the following joints, quite scapiform in itself, and as long as the following three joints together.

CEPHALOPLECTINAE

Cephaloplectus trilobitoides, new species

Length 1.75 mm

Dark reddish brown, form broad, pubescence short, whitish, moderately abundant, pilosity long and fine suberect, arranged in about ten longitudinal rows abdomen rather thickly pilose, apical segment at base with several stiff, though slender, dark, needle-like hairs as long as the segment itself

Head above about four times as broad as long Pronotum transverse, a little longer than the elytra, posterior corners strongly projected and acute, posterior border straight at middle Elytra transverse little narrowed behind, sides moderately arcuate posterior corners slightly projecting and rounded, border straight Abdomen tapering, last segment quadrate, truncate apically Labrum transverse, rounded at sides Penultimate joint of maxillary palpi elongate cylindrical Mesosternum roundly and rather narrowly emarginate behind

Type locality —Esquintla, Guatemala

Type —Cat No 29055 U S N M

Host —*Eciton coecum* Mayr

Related to *Cephaloplectus quadriglume* Wasm, but smaller and proportionately broader and with the posterior corners and pronotum much longer and more acute Described from a single specimen collected by the writer

Cephaloplectus flavus, new species

Length 2.25–2.50 mm

Pale yellow-brown throughout feebly shining, head above thorax and elytra rather densely covered with short and fine yellowish pubescence and with abundant, regular, long stiff very finely tipped sloping hairs abdomen and ventral surface of thorax with recumbent pilosity

Labrum nearly twice as broad as long sides arcuate, anterior border shallowly emarginate Penultimate joint of maxillary palpi cylindrical, three times as long as broad Mentum quadrate transverse Antennae flattened, basal joint short, club not sharply distinct from remainder of antennae intermediate joints very strongly transverse Pronotum distinctly longer than elytra, convex, sides arcuate, posterior corners angulately produced Elytra transverse, posterior corners and border broadly arcuate Abdomen strongly tapering, tip narrow and truncate Prosternum shallowly concave between coxae and a little behind, then convex, posterior border strongly, arcuately emarginate

Type locality —Hamburg Farm Santa Clara, Costa Rica

Type and paratype —Cat No 29056 U S N M

Host —*Eciton*

Differs from *Cephaloplectus quadriglume* Wasm in its more slender form, smaller size and pale coloration Described from two specimens collected by F. Nevermann, one selected as type

Cephaloplectus mus, new species

Length of head, thorax and elytra 2.25 mm. (abdomen strongly contracted)
Broadly oval, convex, moderately shining, coriaceous, rather heavily

pubescent and with abundant, slanting, acute, yellowish hairs; color dark brownish red.

Head above a little less than four times broader than long. Pronotum rather strongly convex above, broader than long and distinctly longer than the elytra, posterior corners projecting and subangulate. Scutellum large and triangular, less than two times as broad as long. Elytra at base as broad as pronotum, sides feebly arcuate, posterior corners very broadly rounded, posterior border straight. Ultimate abdominal segment narrowly rounded at middle. Labrum and mentum transverse. Prosternum broadly and shallowly impressed posterior to coxae, flat behind, posterior border deeply and rather narrowly excavated.

Type locality.—Mera Oriental, Ecuador.

Type and paratype.—Cat. No. 29057 U. S. N. M.

Host.—*Eciton vagans* Smith.

Described from two specimens (one type) taken Feb. 1923 by F. X. Williams in files of the host ant.

This is larger than *Cephaloplectus quadriglume*, the elytra are distinctly broader, the pubescence above much thicker, the scutellum is also proportionately large, in *C. quadriglume* very small.

Cephaloplectus pusillus, new species

Length 1.60 mm.

Pale yellow-brown, shining; pubescence very short and white, not dense; surface finely coriaceous, sparsely punctate, each puncture with a long and fine, nearly erect pale yellow hair.

Head above four times as broad as long; labrum and mentum transverse, flat. Pronotum transverse, distinctly longer than elytra, posterior corners projecting and acute. Elytra individually broader than long, posterior corners less broadly rounded than in *Cephaloplectus flavus*. Last abdominal segment truncate. Abdomen rather thickly pilose and with a few coarser, erect hairs, all golden yellow in color. Mesosternum rather broadly emarginate.

Type locality.—Hamburg Farm, Santa Clara Province, Costa Rica.

Type.—Cat. No. 29058 U. S. N. M.

Host.—*Eciton*.

This species resembles *Cephaloplectus flavus*, but has the posterior angles of the pronotum much more elongate and arcuate, the elytra are much broader (in *C. flavus* each is distinctly longer than broad), and the erect hairs on the dorsal surface are sparse but longer and more erect. Described from a single specimen collected March 3, 1925, by F. Nevermann.

Eulimulodes, new genus

In habitus and general structure resembling *Cephaloplectus* but differing in the maxillary palpi and antennae. The maxillary palpi have the first joint very small, the second about as long as the third, slender basally, triangularly clavate and somewhat compressed apically; the third joint is elongate oval and compressed, obliquely truncate at apex; the terminal joint is thickly subulate. The basal antennal joint is large and nearly as long as the remaining part of antennae excluding the club, the following joints are small and

submoniliform; the club is large and strongly compressed, composed of two broad segments, the apical slightly the longest. The remainder of head and the prosternum are very similar to these parts in *Cephaloplectus*.

Cenotype.—*Eulimulodes mexicanus*, new species.

***Eulimulodes mexicanus*, new species**

Length 2 mm.

Brownish red. Broadly oval, tapering behind, coriaceous, closely seriolately pilose, the pile short and appressed, pale yellow, almost white; surface moderately shining.

Portion of head visible from above three times as broad as long, its anterior border forming an even arc with the sides of pronotum; labrum slightly transverse, a little broader behind than in front, sides straight, anterior border shallowly emarginate and with an impressed space near margin. Penultimate joint of maxillary palpi broad, subovate and compressed, terminal joint subulate and about three-eighths as long as the penultimate. First antennal joint nearly as long as side of labrum, club oval, strongly flattened, the two joints subequal in length and very much broader than the moniliform joints between it and the basal. Pronotum a little broader than long, about as long as elytra, strongly convex, sides arcuate, posterior corners moderately produced and narrowly rounded, posterior border nearly straight. Scutellum very broadly triangular. Elytra at base a little narrower than pronotum, together broader than long, narrowed behind; posterior corners broadly rounded, border nearly straight. Abdomen moderately tapering, apical segment shallowly emarginate at tip; dorsal surface with abundant, recumbent, long and fine black hairs. Ventral surface shining, pilosity longer, finer and less appressed than on dorsal surface. Prosternum broadly convex except between coxae, where it is flatter, triangulately emarginate behind.

Type locality.—Ixthán, Nayarit, Mexico.

Type and paratype.—Cat. no. 29059 U. S. N. M.

Host.—*Eciton (Acamatus) wheeleri* Emery.

Described from two specimens (one type) taken with the host, out from beneath a stone, by the author.

Cephaloplectus godmani Sharp from Panama is a much larger species and the pronotum is proportionately longer. *Cephaloplectus quadriglumis* Wasm. which lives with *Eciton quadriglume* Hal. is similar in habitus but lighter in color and above with erect hairs, lacking in *Eulimulodes mexicanus*. The emargination of the posterior margin of prosternum is more broadly angulate and all of these have the third joint of the maxillary palpus long and slender and the antennal joints broad.

This species resembles an exceedingly large *Limulodes* and sufficient material for dissection may show a close relationship between the two.

***Xenocephalus lucidus*, new species**

Length 3.5 mm.

Yellowish brown, minutely and sparsely punctate and shining, a few delicate striolae visible on front margin of head, without hairs above.

Form elongate, strongly convex above. Head from above four times as broad as long, arcuate in front and behind, with small, lumate portions of the eyes visible at sides. Pronotum transverse, at middle slightly shorter than

elytra, anterior border broadly emarginate, anterior corners rounded, sides arcuate, posterior corners slightly projecting and more narrowly rounded than the anterior ones; posterior border feebly arcuate. Elytra at base as broad as pronotum, transverse, sides, seen from directly above, nearly straight and parallel, very slightly projected and rounded at posterior corners, posterior border feebly sinuate. Abdomen at base a little narrower than elytra, moderately tapering, posterior corners of dorsal sclerites angulate, penultimate sclerite with six triangular teeth at apex. Head from beneath rather flat between eyes. Labrum transverse, strongly emarginate anteriorly. Eyes large, more than twice as long as broad and with very large facets. Antennae barely reaching anterior margin of head, basal joint two-thirds as long as eye, somewhat compressed, second joint cylindrical and two times as long as broad, remaining joints, except the terminal, transverse and forming a compressed club, terminal broadly oval and shorter than the two preceding joints together. Maxillary palpi elongate, second joint arcuate, clavate at apical half, third joint as long as second, slender, feebly thickened toward apex, fourth joint thickly subulate, two-thirds as long as the third. Legs short and strongly compressed.

Type locality.—Hamburg Farm, Santa Clara Province, Costa Rica.

Type and paratype.—Cat. no. 29060 U. S. N. M.

There are sparse microscopic hairs, barely visible, at the lateral and posterior margins of the elytra, more at the apices of the dorsal abdominal sclerites, otherwise the dorsal surface is glabrous. On the ventral surface and legs there is rather sparse and fine yellowish pilosity and at the apices of the abdominal segments a few erect, stiff black hairs.

This is an unusually narrow species. Described from two specimens collected by F. Nevermann, one being selected as type.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

693D MEETING

The 693d meeting was held in the assembly hall of the Cosmos Club April 24, 1926 at 8:10 p.m., with President OBERHOLSER in the chair and 61 persons present. New members elected: JAMES O. MALONEY, S. PRENTISS BALDWIN (life member).

C. W. TOWNSEND described a recent trip with T. GILBERT PEARSON through the southern states in search of birds. They visited Miss ABBIE AUDUBON, 90 years old, the granddaughter of AUDUBON. At King Ranch, Texas, an unsuccessful search was made for the whooping crane. The quail study station in southern Georgia, in charge of Mr. STODDARD, was visited, and a call was made upon ARTHUR WAYNE at Mt. Pleasant, S. C. In Florida, roseate spoonbills, limpkin, and everglade kites were seen.

A. WETMORE gave an account of an egg recently laid at the Zoological Park by a California condor. Three birds of this species have been at the Zoo for many years. The two eggs laid in previous years have been accidentally broken by the birds. The egg laid this year was put under a hen, but did not

hatch, and is now in the National Museum. The egg is very similar in appearance to that of a goose. An amateur collector once sent one to the Museum which he had bought for \$500, but which proved under microscopic examination to be a goose egg. H. C. OBERHOLSER stated that a collector had once sent Major BENDIRE eggs said to be those of a rare Florida hawk, which presented a peculiar appearance about the blow-hole, and which proved to be painted pullet's eggs.

S. PRENTISS BALDWIN, Cleveland, Ohio: *Intensive study of the life history of birds*.—The speaker described his work in bird banding at Cleveland, Ohio, and at his Georgia station. During 10 years he has banded about 50,000 birds. Special attention has been devoted to the house wren, of which 12 to 15 pairs nest on his grounds near Cleveland. Aided by several young ornithological assistants, close watch is kept on the birds' actions all day long. The eggs are weighed daily, and the order of laying and hatching is noted, as well as the gain in weight of the nestlings and many other matters. The birds quickly become familiar and recognize individuals. In addition to numbered bands for individual birds, sex bands of different colored celluloid are used for convenience in studying the actions of the birds. The sexes are distinguished by song, flight, method of entering nest boxes, etc. The male migrates north first and at once adopts a certain territory for his own. The birds raise two broods each year and generally change mates between broods. Young birds are led off by their parents when very young and almost never come back to the same nest box. No cases of interbreeding have been noted.

S. PRENTISS BALDWIN: *Life history of the house wren* (illustrated).—The speaker showed two reels of moving pictures exhibiting the nesting activities of the house wren, and the method by which these were recorded.—Discussed by L. J. COLE, E. P. WALKER, A. WETMORE, and R. M. LIBBY.

694TH MEETING

47TH ANNUAL MEETING

The 694th regular and 47th Annual Meeting was held in the new lecture hall of the Cosmos Club, May 8, 1926 at 8:10 p.m., with President OBERHOLSER in the chair and 20 persons present. The minutes of the previous Annual Meeting were read and approved.

The annual reports of the Recording Secretary, Corresponding Secretary, Treasurer, and Publications Committee were read and ordered placed on file. B. H. SWALES, for the Auditing Committee, reported that the Treasurer's accounts had been found correct. S. A. ROHWER gave an informal report for the Committee on Communications.

After the suspension of the By-laws, the following new members were elected: Dr. FRANCIS R. HAGNER, Dr. T. GILBERT PEARSON.

S. A. ROHWER moved the suspension of the By-laws and the re-election of the officers elected last December, which was carried unanimously. The officers of the Society for the ensuing year are as follows:

President, H. C. OBERHOLSER; *Vice-Presidents*, E. A. GOLDMAN, A. WETMORE, C. E. CHAMBLISS, H. H. T. JACKSON; *Recording Secretary*, S. F. BLAKE; *Corresponding Secretary*, T. E. SNYDER; *Treasurer*, F. C. LINCOLN; *Members of Council*, H. C. FULLER, W. R. MAXON, C. W. STILES, A. A. DOOLITTLE, B. H. SWALES.

S F. BLAKE, *Recording Secretary*.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 16

OCTOBER 18, 1926

No. 17

RADIOTELEGRAPHY.—*Direction determinations of atmospheric disturbances on the Isthmus of Panama.*¹ L. W. AUSTIN. Laboratory for Special Radio Transmission Research.²

It has long been known that atmospheric disturbances in general originate over land rather than over the ocean. It is also known that the sources of the tropical disturbances seem to follow the sun in its changing path between the northern and southern hemispheres.³ It was therefore to be expected that during the winter in Panama, (10° north), the atmospheric disturbances would come chiefly from the mainland of South America, while in summer they might be expected to come from the direction of Central America and Mexico. In addition, during the rainy season, it could be assumed that there would be a considerable amount of local disturbance generated in the low mountain chain which forms the backbone of the isthmus. It was not known, however, whether these local disturbances would outweigh those coming from the larger land masses.

During February and March, 1925, I made directional observations on atmospheric disturbances at frequencies of 21.4 and 15 kc. (14,000 and 20,000 m.) in the U. S. Naval radio receiving stations at Balboa and Colon, at the two ends of the Panama Canal. The measurements were afterward continued by the personnel of the two stations.

The method used in the measurements was first described in 1920.⁴ The apparatus shown in the figure, consisted of an 8 ft. (2.44 m.) coil antenna with 48 turns, which was combined with a small single wire

¹ Received May 5, 1926. Published by permission of the Director of the National Bureau of Standards of the Department of Commerce.

² Conducted jointly by the Bureau of Standards and the American Section of the International Union of Scientific Radio Telegraphy.

³ DeGroot, Proc. I. R. E., 5: 75. 1917. GOLDSCHMIDT and BRAILLARD, La T. S. F. (Congo Belge), HAYES (Bruxelles) 1920. AUSTIN, Journ. Franklin Inst. 191: 619. 1921. ROUND, ECKERSLEY, TARMELLEN & LUNNON, Journ. I. E. E. (London), 62: 62. 1925.

⁴ AUSTIN. Journ. Franklin Inst. 191: 619. 1921.

antenna to form a unidirectional receiving combination. In the measurements the general direction was first found by rotating the coil and adjusting the antenna coupling and resistances until the disturbance maximum was obtained with the antenna reversing switch

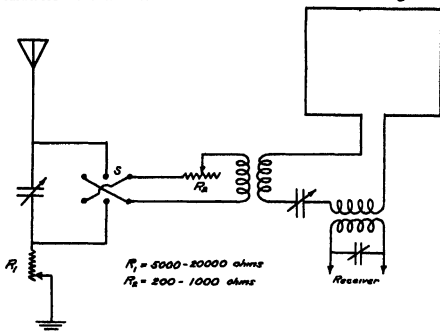


Fig. 1—Diagram of directional receiving circuit

S thrown in one direction and the minimum when it was thrown in the other. The absolute direction in which signals were strengthened with the switch in a certain position was determined by observations on a transmitting station in a known direction. When the general direction had been determined, the coil was turned approximately at right angles to the indicated disturbance direction, the switch S was then rapidly reversed, the coil being at the same time slowly moved until the position was found in which the sound of the disturbances in the telephones was of the same intensity with the switch in its two positions. In general there were a certain number of degrees on the coil scale over which the sound equality was maintained. The center of this zone of equality was the scale reading for which the coil was at right angles to the average disturbance direction, since in this position the coil was inactive, the whole reception being from the antenna. By this method good readings can be obtained when no direction at all can be observed on the coil antenna alone.

Table 1 shows the results of the observations from February to November, 1925. Those taken from February to the end of June were made by observers who had received personal instruction in the method of measurement and are considered more reliable than those taken later. Owing to changes in the personnel of the stations, the work was apparently entirely interrupted during July and August. During the months in which accurate measurements were generally possible, the bearings in the table are given in degrees. During the more disturbed periods the directions are only roughly indicated.

TABLE 1.—DIRECTION OF ATMOSPHERIC DISTURBANCES AT BALBOA AND COLON

BALBOA				COLON			
		Number of observations			Number of observations		
Feb.	3 p.m.	10	All (120°-130°) ^a	—	—	—	—
March	10 a.m.	—	—	10 a.m.	9	All (120°-130°) ^a	—
	3 p.m.	25	All (125°-135°)	3 p.m.	9	All (130°-140°)	—
	10 p.m.	—	—	10 p.m.	9	All (120°-140°)	—
April	10 a.m.	7	7 NB ^a	10 a.m.	23	All (120°-145°)	—
	3 p.m.	29	20 NB, 7 SE, 1N, 1E	3 p.m.	25	All (130°-145°)	—
	10 p.m.	7	5 NB, 2N	10 p.m.	23	All (120°-140°)	—
May	10 a.m.	9	4 NB, 5 (NW-N)	10 a.m.	16	2 NB, 14 SE	—
	3 p.m.	31	15 NB, 15(NW-N), 1 NE	3 p.m.	13	2 NB, 11 SE	—
	10 p.m.	9	8 NB, 1 NE	10 p.m.	3	3 SE	—
June	10 a.m.	9	3 NB, 6N	10 a.m.	15	All SE	—
	3 p.m.	30	5 NB, 25 N	3 p.m.	14	All SE	—
	10 p.m.	9	9 NB	10 p.m.	4	All SE	—
No observations in July and August							
Sept.	—	—	—	10 a.m.	30	1 NB, 29 SE	—
	—	—	—	3 p.m.	30	1 NB, 28 SE, 13	—
	—	—	—	—	—	—	—
Oct.	10 a.m.	31	26(NW-NE), 5 SE	10 a.m.	31	All (130°-140°)	—
	3 p.m.	31	3 NB, 23(NW-NE), 5 SE	3 p.m.	31	All (130°-145°)	—
	10 p.m.	31	25 NB, 5(W-N), 1SE	—	—	—	—
Nov.	10 a.m.	30	19(E-SE), 8(NW-NE), 3(S-W)	10 a.m.	30	All (135°-140°)	—
	3 p.m.	30	1 NB, 20(SE-S), 3(SW-W), 6(NW-NE)	3 p.m.	30	All (130°-145°)	—
	10 p.m.	15	13 NB, 1SE, 1NE	—	—	—	—

^a NB = no definite bearings.

^b The angles are measured clockwise from north.

The data obtained seem to warrant the following conclusions:

1. During the dry season, probably from January 15 to April 1, the atmospheric disturbances both at Balboa and Colon come almost entirely from the South American continent, from the direction of the high Andes in northern Colombia.

2. When the dry season comes to an end and local storms begin to appear, the local disturbances from the low mountains of the isthmus begin to be prominent. This shifts the prevailing direction at Balboa at times from the southeast to the north, but has little effect on the direction at Colon since the mountains containing the local centers of disturbance here lie to the south and east, or roughly in the direction of the disturbance sources in Colombia.

3. In midsummer, while there is probably much disturbance from Central America and Mexico, the local disturbances from the isthmus mask this to such an extent that the prevailing direction at Colon continues roughly southeast, while at Balboa the distant and local disturbances unite to give a northerly or northwesterly direction.

4. The observations further indicate that from northern sending stations, Balboa and Colon should give nearly equally good unidirectional reception in the dry season, but during the rest of the year, where the disturbance conditions are more troublesome, Colon should have considerable advantage over Balboa.

GEOLOGY.—*Major features in the geology of the Atlantic and Gulf Coastal Plain.*¹ L. W. STEPHENSON, U. S. Geological Survey.

GEOGRAPHIC EXTENT AND TOPOGRAPHY

The Atlantic and Gulf Coastal Plain is a sharply defined geologic unit, and a somewhat less sharply defined physiographic unit, throughout most of its extent in the United States. The length of the plain from Cape Cod, Mass., to the Rio Grande is in round numbers 2,000 miles. The Atlantic portion of the plain (exclusive of Florida) is much narrower than the Gulf portion, the former averaging about 100 miles in breadth and the latter (exclusive of the Mississippi Valley) averaging about 250 miles. The Mississippi Valley from the Delta to Cairo is about 570 miles long and the Peninsula of Florida about 400 miles long. This vast so-called plain rises from sea level on the coast to a maximum of somewhat more than a thousand feet in parts of Texas, and there is in general a rise in the altitude of the inner margin of the plain from a little more than 100 feet in places on Cape Cod

¹ Presidential address read before the Geological Society of Washington, December 9, 1925. Published by permission of the Director, U. S. Geological Survey. Received September 18, 1926.

(disregarding hills of glacial upthrust which are nearly 300 feet high) in the northeast to over a thousand feet in Texas.

Beyond the Rio Grande in Mexico the country that can properly be classed as Coastal Plain narrows rapidly toward the south, the inner margin approaching to within a few miles of the coast, and from the vicinity of Tampico southward to Yucatan is represented only by narrow areas bordering the coast. In Yucatan the plain broadens out again to large proportions, practically the whole of the peninsula presenting a coastal plain aspect. In eastern Mexico, however, no serious attempt has as yet been made to determine the exact boundaries of the areas that should be classed as coastal plain.

Although we ordinarily think of the Coastal Plain as ending at the coast, it does not in reality end there but extends out under the sea to the edge of the Continental Shelf, the position of which is shown on the map. In other words, a part of the Coastal Plain is submerged to maximum depths of about 600 feet. Off the New England coast the entire Coastal Plain goes out to sea and is completely submerged. At the edge of the Continental Shelf the submerged surface plunges steeply to the abysmal depths of the ocean.

Although the term "coastal plain" seems to suggest a region of level topographic aspect, the Atlantic and Gulf Coastal Plain is by no means a featureless plain. The province does present extensive tracts of nearly level plain, but other extensive areas range from rolling to sharply hilly. Examples of the former are the broad marine terrace plains which are more or less clearly developed and preserved from the Eastern Shore of Maryland southward to Florida, and the alluvial terrace plains of all the larger streams crossing the Coastal Plain, the finest and broadest examples of which are in the valley of Mississippi River. The hilly topography occurs in the higher, dissected, inter-stream areas, especially along the inner margin of the Coastal Plain from the Carolinas southwestward to Mississippi Valley, and beyond the Mississippi in Arkansas, Louisiana, and Texas. Locally there are rough forest-covered tracts of dissected upland of unbelievable wildness, several examples of which are: the Cretaceous sand hills in Cumberland and Scotland counties, North Carolina, and similar hills in Marlboro, Chesterfield and Kershaw counties, South Carolina; the Cretaceous hills along the inner margin of the Coastal Plain in Alabama; the Tombigbee River hills, and the hills of the Pontotoc Ridge, in northern Mississippi; and the Tertiary hills of Anderson and Cherokee counties, Texas.

CHARACTER AND FORM OF SEDIMENTS

The Coastal Plain is underlain by a series of sedimentary formations composed of sands, clays, marls, limestones, and chalks, and subordinately of gravels, diatomaceous earths, water-laid volcanic materials, and common salt in the form of plugs or so-called salt domes. Locally in Arkansas and Texas the sediments have been cut by intrusive igneous rocks. The thick accumulations of chalk and limestone are restricted to the south Atlantic and Gulf Coastal Plain. These various materials are mainly unconsolidated or only partly consolidated, though some indurated layers occur interbedded with the softer beds, and they range in age from Lower Cretaceous to Recent. They rest upon a basement of much older consolidated rocks which range in age from pre-Cambrian to Triassic. The different kinds of materials do not form separate uniform sheets extending throughout the entire length of the Atlantic and Gulf Coastal Plain, for the sediments laid down at any given time differed from place to place, and the conditions of sedimentation constantly shifted from time to time. Briefly stated, this means that no two columnar sections, unless closely adjacent to each other, are identical in lithologic succession. This diversity in the succession of formations in different sections is one of the chief difficulties encountered by the stratigrapher and paleontologist in determining the age and stratigraphic relationships of the formations.

Viewed as a whole the sediments of the Coastal Plain form a wedge-shaped mass along the eastern border of the continent, with the blade of the wedge represented by the thin feather edge along the inner margin of the plain. The thick end of the wedge along the coast ranges in thickness from a measured minimum of 1,540 feet at the mouth of Cape Fear River in North Carolina, to an unknown maximum probably beneath the Mississippi Delta in southern Louisiana, which may reach 10,000 feet or more. A well 5,283 feet deep, slightly more than a mile, near Pascagoula in southern Mississippi, and one 6,027 feet deep near Lockport in southwestern Louisiana, may not have penetrated half the full thickness of the sediments, though this is conjectural. The form of this wedge of sediments is extremely attenuated in cross section, far more so than we ordinarily conceive of, due to the fact that most of its published graphic cross-sections are necessarily exaggerated in the vertical scale anywhere from 10 to 50 times. To get a true picture of such a cross-section one need only plot it to its true scale. If, for example, we draw a section across the Coastal Plain in the Cape Fear region of North Carolina, where the width of the plain is about

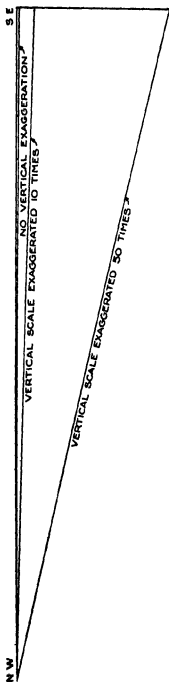


FIG 1.—Ideal section across the Atlantic Coastal Plain showing the greatly attenuated form of the wedge of Coastal Plain sediments. The section is 100 miles long and increases in thickness from a feather edge at the left to 1,500 feet at the right.

100 miles and the thickness of the sediments at the coast is 1,540 feet, taking the length of the section as 10 feet, its coastward end would be only about a third of an inch thick (See fig 1.) In the Mississippi Valley, where the width of the Coastal Plain from north to south is 570 miles, if we assume a thickness of sediments at the mouth of Mississippi River of 10,000 feet, the thickness of a section 10 feet long would be only two-fifths of an inch at the Delta end. With a wedge of sediments so extremely thin as this, only relatively slight crustal movements are required to account for the known tilting and warping.

The sediments of the Coastal Plain do not end at the coast, but extend out under the sea, and if the basement surface on which they rest continues to slope uniformly the mass of the sediments must increase in thickness at least as far as the edge of the Continental Shelf, beyond which they should thin out rapidly as they merge into the oozes of the ocean depths.

ORIGIN OF THE SEDIMENTS

A very large part of the sediments of the Coastal Plain was brought into the sea by streams entering from adjacent land areas, and was derived from sedimentary and igneous rocks ranging in age from pre-Cambrian to Triassic. Lesser portions were derived partly by the

direct action of the waves of the sea itself, eating into the edge of the land along the shores, partly from the precipitation of calcium carbonate from the sea water, partly from the accumulation of calcareous and siliceous shells and skeletons of various marine organisms, both small and large, and partly from the formation on the sea bottom of the iron potassium silicate, glauconite. The sediments were laid down on the Continental Shelf in marine waters generally less than 100 fathoms deep, some in water so deep as not to be disturbed by wave action during their deposition, and therefore acquiring massive structure; some in shallower water near the lower limit of wave action, and consequently exhibiting cross-bedded structure of fine pattern; and some in water so shallow as to show strong, coarse cross-bedding. The latter were for the most part laid down near shore in the sea itself or in bays and lagoons, and are either coarse or fine in texture depending upon the character of the material carried into the sea at the time of their formation. A subordinate part of the sediments was deposited on river flood plains closely adjacent to the sea. The texture of the sediments was determined in part by the kind of material fed to the sea, in part by the strength and distribution of currents, and in part by the proportional amount of precipitated matter, and the amount and character of the organic remains entering into their composition. The degree of hardness was determined partly by the presence or absence of cementing matter, such as calcium carbonate, silica, and iron oxide, and partly by the weight of overlying sediments. The amount of the available material is by no means the only factor that determines the thickness of sediments. In order that marine sediments may continue to increase in thickness it is necessary that the sea bottom on which they are accumulating should continue to subside either by tilting or by direct downsinking, or that the level of the sea should rise, for these sediments cannot pile up higher than the level of the sea. Upon reaching nearly to sea level, instead of piling up they will be carried farther seaward by the currents and spread over a broader area. This is why a thickness of 100 or 500 feet of marine sediments in the Coastal Plain may represent as great a period of geologic time as 5000 or 10,000 feet in certain other parts of the world, as in California and in parts of South America. The ideal condition for the accumulation of great thicknesses of marine sediments is highly uplifted land areas closely adjacent to deeply subsiding sea bottoms. The reverse conditions, in which land areas undergo slight or moderate uplift, and adjacent sea bottoms sink slowly and to only moderate depths, result

in the accumulation of formations of thin to moderate thickness. It was under the latter conditions that most of the formations of the Coastal Plain were laid down, and the minimum thickness is found in the northern part, in Maryland, Delaware, and New Jersey. Here 25 or 50 feet of sediments may represent the time interval of 500 or 1,000 feet in the Gulf portion, where the maximum thicknesses occur. It may perhaps be fairly assumed that the greatest thicknesses exist in the Mississippi Embayment where an abundance of material has been continuously supplied by Mississippi River and its tributaries during Cretaceous and Tertiary time, and where subsidence has been greatest.

GEOLOGIC HISTORY AS EXPRESSED IN THE MAP

Although a complete history of the Coastal Plain would include in its scope the formation of the basement rocks upon which the sediments of the Coastal Plain rest, for the purposes of this paper I will go back only to that period of geologic time immediately preceding the deposition of the earliest of these sediments. In early Cretaceous time all of the Coastal Plain was a land area undergoing erosion, and the exposed rocks ranged in age from pre-Cambrian to Triassic. In the Atlantic Coastal Plain the rocks were pre-Cambrian crystalline rocks with the exception of a few small areas of land-laid sedimentary rocks of Triassic age, preserved in down-faulted basins within the crystallines. In the Gulf Coastal Plain the rocks were, so far as known, chiefly Paleozoic, ranging in age within that era from Cambrian to Permian, with, however, some areas of ancient pre-Cambrian crystalline rocks.

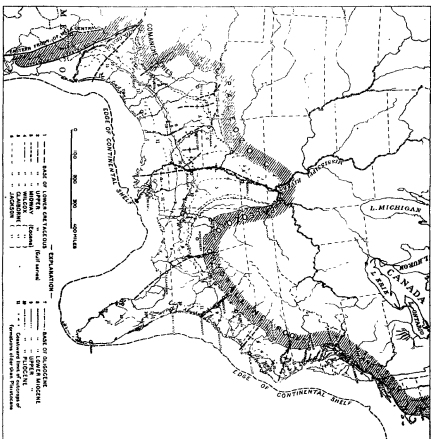
If we could construct a moving picture film of the events that have played the major part in the upbuilding of the Coastal Plain on this basement of older rocks, and could speed up that film so as to bring the picture within the limits of the present hour, we would observe the sea in a remarkable succession of advances and retreats, and after each retreat we would see left behind layers of sediment of greater or less thickness and extent constituting one of the contributions to the construction of the Coastal Plain. The sum total of these contributions, as the picture would appear at the end of the reel, would be the Coastal Plain in form and outline as we see it today. The accompanying sketch map (plate 1) is an attempt to show graphically how the Coastal Plain has been gradually built up during the time that has elapsed from the Lower Cretaceous epoch to the present.

The lines numbered from 1 to 11 show the approximate position of the

present inner, or landward, edges of the deposits that were laid down during the successive geologic epochs and periods, and it will be observed that in general, but with certain exceptions, the lines bearing the successively higher numbers occupy positions successively nearer the present coast. The deposits of each period formerly extended farther inland than their present landward limit, erosion having bevelled off their exposed edges for undetermined distances seaward from their original landward limit, in places doubtless amounting to several miles. As the width of the eroded belts varies greatly with respect to the deposits of the different periods, and also from place to place along the linear extent of the outcrop of the deposits of any period, it is not possible to show the original inner limits of the deposits. It will be observed that in places the lines marking the landward limits of the younger formations sweep inward obliquely across those marking the landward limits of the older formations, and these are the exceptions to which reference was made above, where transverse warping caused the sea to transgress farther inland than would have been the case had there been no such differential warping. Some of the more important features that are brought out by these lines are explained below.

Line 1.—This line shows the inner edge of Lower Cretaceous marine deposits (Comanche series) in the western Gulf region, and the inner edge of Lower Cretaceous continental deposits (Potomac group) in the Chesapeake and Delaware Bay region. No Lower Cretaceous deposits of marine origin are known east of Mississippi River though they may be present, deeply buried beneath the overlying younger sediments in parts of the eastern Gulf and Atlantic Coastal Plain not yet reached by the drill. The Lower Cretaceous sea submerged the western Gulf region, but so far as we know, did not submerge the eastern Gulf nor the Atlantic Coast region. In the western Gulf region the submergence was not restricted to the Coastal Plain, but spread far to the northwestward up the valley of the Rio Grande, and far to the westward, southwestward, and southward, covering nearly all of what is now the high Mesa Central of Mexico. The continental deposits of the Potomac group in the north Atlantic Coastal Plain were laid down on a low plain presumably bordering the coast of that time, though it has not been demonstrated that the strand line was any farther inland then than it is at the present time. Following the deposition of the Comanche series in a sea which covered most of the western Gulf region and most of Mexico, there was an uplift of the land which brought the submerged region above sea level and subjected it to erosion. Thus we have in Texas, Oklahoma, and Arkansas, an unconformity between the Comanche series and the overlying Gulf series.

Line 2.—This line shows the inner edge of the Upper Cretaceous deposits (Gulf series), including marine and non-marine sediments. The Atlantic and Gulf Coastal Plain tilted seaward, allowing the ocean waters to spread over most of the Coastal Plain from southern New England to Mexico. In Mexico the sea extended west of the present Coastal Plain, even encroaching



in places on the eastern border of what is now the Mesa Central, but probably most of central and western Mexico remained above the sea. This submergence, if restricted in its extent in Mexico, was far more extensive in the west-central and northwestern parts of the continent than the preceding Comanche submergence. An area of vast extent embracing the Great Plains and Rocky Mountain regions of the United States and Canada, was down-warped allowing the waters of the Gulf to spread inland through what is now the Rio Grande Valley region, forming a great epicontinental sea which probably extended northward entirely across the continent connecting with the waters of the Arctic Ocean. In the Coastal Plain itself the great geosynclinal valley known as the Mississippi Embayment had its initial downwarping allowing the sea to encroach northward in the form of a deep embayment having its head at the southern extremity of Illinois. During the deposition of the Upper Cretaceous sediments in and along the borders of the ocean of that period there were oscillations and warpings of the land with respect to sea level which caused minor retreats and advances of the strand line, and each such retreat is marked in the sediments by an unconformity of relatively short time significance, but at the close of the period there was a general continental uplift which freed the land of its flood of ocean waters and forced the strand line oceanward perhaps as far as the edge of the Continental Shelf. Erosion throughout the extent of the newly emerged surface produced the regional unconformity which separates the Upper Cretaceous from the overlying Eocene sediments.

Line 3.—The inner edge of the oldest Eocene deposits, those of the Midway group, is shown by line 3. The Midway sea was much more restricted in its extent than the preceding Upper Cretaceous sea; it did not cover all of western Texas and, so far as known, none except the extreme southern portion of the Atlantic Coastal Plain; it did, however, sweep northward to the head of the Mississippi Embayment, and in Georgia reached almost to the inner edge of the Coastal Plain. In parts of the Gulf region there is an unconformity between the deposits of the Midway group and those of the overlying Wilcox group, and where present this break marks a retreat of the sea.

Line 4.—This line shows the inner edge of the deposits of Wilcox Eocene age, which overlie the Midway. The line lies just a little nearer the Coast than Line 3. It extends to the head of the Mississippi Embayment but the Wilcox sea did not spread this far to the northward for the deposits in the northern part of the Embayment are of non-marine origin, probably having been laid down on the flood plain of an ancient Mississippi River, or perhaps in part as delta deposits at the mouth of the same river. In Georgia the Wilcox deposits are overlapped and concealed by younger deposits (see Line 7), but they reappear again in a small area in the eastern part of South Carolina. Several remnants of shallow marine deposits of Wilcox age (identified by Dr. Wythe Cooke) occur on the upland resting on the Cretaceous near the inner edge of the Coastal Plain in North Carolina, and one such

remnant (also identified by Cooke) occurs resting on crystalline basement rocks a few miles east of Raleigh. Whether these remnants indicate a complete transgression of the sea over eastern North Carolina, or were laid down in a restricted embayment is not known. If, however, Wilcox deposits were ever laid down over all of the North Carolina Coastal Plain they were later largely removed by erosion, for they are wanting over most of the area, and younger deposits of Jackson Eocene age, rest directly upon the Cretaceous in the vicinity of Wilmington. No attempt has been made to represent on the map the shore line of the sea in which these remnants were laid down. The Eocene is completely overlapped by upper Miocene deposits in the northern part of the North Carolina and southern Virginia Coastal Plain, but the Wilcox Eocene, represented by the Pamunkey group, reappears farther north, within a few miles of the inner edge of the Coastal Plain in Virginia, Maryland, and Delaware.

Line 5 — The inner edge of the deposits of Claiborne Eocene age is shown by this line. The Claiborne sea was more restricted in extent than the Wilcox sea, and the Claiborne waters fell far short of reaching the head of the Mississippi Embayment. The deep southward indention of Line 5 in northeastern Texas and northwestern Louisiana, marks the position of the Sabine uplift, the axis of which is shown on the map. The Claiborne deposits were probably laid down over all of this area but were eroded away as a result of the uplift. They are almost overlapped by younger deposits in eastern Alabama, and, although revealed in places by erosion along drainage lines in Georgia and southwestern South Carolina, the area in which they occur in that State was completely transgressed by the next younger or Jackson sea. Claiborne deposits have not been identified either in surface outcrops or in wells anywhere in the Atlantic Coastal Plain north of South Carolina.

Line 6 — The inner edge of the Jackson, the youngest deposit of the Eocene, is shown by this line. It indicates a still greater restriction of the sea in the Gulf Coastal Plain in late Eocene time. However, a renewal of the downwarping in the Mississippi Embayment carried an arm of the Jackson sea at least as far north as had been reached by the Claiborne sea and perhaps a little farther. In the south Atlantic Coastal Plain a broad downwarp allowed the sea to sweep inland across all older deposits to the inner edge of the Coastal Plain in eastern Georgia and southwestern South Carolina. Farther north a broad upwarp having its axis near the boundary between North Carolina and South Carolina forced the Jackson strandline outward almost to the present coast, where the deposits of Jackson age may now be seen resting unconformably on the Upper Cretaceous. Farther north in North Carolina the Jackson deposits, represented by the Castle Hayne marl, pass under the Miocene and are not known anywhere in the North Atlantic Coastal Plain.

Line 7. — This line marks the inner edge of the Oligocene deposits which are represented by the Vicksburg group. In southern Texas the Oligocene deposits, as here interpreted, are completely overlapped by lower Miocene deposits, and are known only in wells. The line starts in eastern Louisiana

a few miles south of Line 6. Where it crosses Mississippi Valley the line is markedly convex to the north, but falls 200 miles short of reaching as far north as Line 6, apparently there was only slight downwarping in the Embayment during Oligocene time. Through eastern Mississippi and western Alabama Line 7 lies only a few miles south of Line 6. In eastern Alabama and western and central Georgia and Oligocene sea made a decided transgression to the north over the Eocene deposits, for Line 7 cuts obliquely across lines 6, 5, and 4, and in the vicinity of Macon the sea reached to within a few miles of the inner edge of the Coastal Plain. In eastern Georgia the Oligocene strata (Clendon chert) are in turn transgressed and concealed by Miocene deposits except in one relatively small area in Savannah River Valley, where erosion has uncovered them. No occurrences of Oligocene strata are known either in wells or outcrops anywhere in the Atlantic Coastal Plain north of the last mentioned area. The Catahoula sandstone of Mississippi, which has heretofore been correlated with the Oligocene, is believed by Doctors Wythe (Cooke and Julia Gardner to be of lower Miocene (Aquitanian) age, and it seems probable that the Catahoula of Louisiana and Texas are also of lower Miocene age. It is on this assumption that Line 7 is not extended across Louisiana into Texas. Marine Oligocene representing the Vicksburg group has, however, been recognized in wells in southern Texas, showing that beds of this age are present there beneath younger beds.

Line 8.—Deposits of lower Miocene age are found inland as far as Line 8. In certain places these deposits carry marine fossils and were obviously laid down in marine waters of moderate depth. A considerable part of the deposits are, however, not of typical marine origin, but their distribution parallel to the coast suggests that their deposition was controlled by sea level. They were doubtless laid down in part in the shallow littoral waters of the sea, in part in bays, lagoons, and estuaries, in part in deltas, and in part as flood plain deposits on low plains bordering the sea. In determining the position of this line in Mississippi, Louisiana, and Texas, the opinions of Doctors Wythe Cooke and Julia Gardner, already cited, that the Catahoula sandstone in Mississippi belongs to the lower Miocene, is accepted. Some investigators regard this formation as Oligocene, and in Louisiana and Texas as contemporaneous in part with the Vicksburg group. In eastern Georgia the lower Miocene (Alum Bluff group) transgresses inland across Oligocene and Eocene formations to within 20 miles of the inner edge of the Coastal Plain, but in the southern part of South Carolina, Line 8, marking the inner edge of the Alum Bluff deposits, swings to the southeast and comes to the coast. North of this lower Miocene deposits have been recognized only in a limited area in eastern North Carolina (Trent marl), as indicated on the map. Apparently most of the Atlantic Coastal Plain north of South Carolina was above sea level and undergoing erosion in lower Miocene time. In Florida Line 8 outlines an island of upper Eocene deposits belonging to the Ocala limestone (of Jackson age) on the north, east, and south sides of which are overlapping deposits of lower Miocene age. This island-like area may once

have been covered by lower Miocene deposits which were later removed as a result of slight uplift and erosion.

Line 9.—This line, which marks the inner limit of deposits of upper Miocene age, shows a marked restriction of the sea of this time in the Gulf region as compared with the landward spread of all the earlier seas which participated in the upbuilding of the Gulf Coastal Plain. From southern Alabama westward the upper Miocene deposits were completely overlapped and concealed by the deposits of the next younger epoch, the Pliocene, and were later uncovered by erosion in the valleys only, in limited areas in southern Alabama, Mississippi, and Louisiana. Only relatively small areas in Florida and Georgia were covered by the waters of the upper Miocene sea, but from South Carolina northward to New Jersey there was marked transgression of the sea inland across the Atlantic Coastal Plain, the maximum submergence being in the northern part of North Carolina and in Virginia where the sea completely covered the Coastal Plain to its inner edge. In eastern South Carolina and southeastern North Carolina this upper Miocene transgression is indicated only by scattered erosion remnants of Miocene sediments occupying shallow depressions in the eroded surface of Upper Cretaceous deposits, but farther north the sheet of upper Miocene deposits is continuous, reaching a maximum thickness of several hundred feet.

Line 10.—This line marks the inner edge of deposits of Pliocene age. In the Gulf Coastal Plain these sediments are largely of non-marine origin, and were apparently laid down chiefly as coalescing alluvial accumulations on a low plain bordering the coast. In Mississippi and western Alabama these deposits (the Citronelle formation) spread northward across Miocene, Oligocene, and uppermost Eocene formations, but they are relatively thin, and the underlying overlapped formations are exposed by erosion in all except the smaller headwater valleys. A broken line is used to show this northward transgression of the Pliocene over older formations. The Pliocene is represented by marine deposits at a few localities in Florida and along the Atlantic Coast as far north as the southern part of North Carolina. These occurrences mark small embayments which extended a few miles inland. Mr. W. C. Mansfield has recently identified marine Pliocene marls along the shores of Neuse River south of New Bern, N. C. At many places on the higher interstream uplands of the Coastal Plain are erosion remnants of greater or less extent, of relatively thin surficial deposits of gravel, sand, and loam. These were laid down by ancient rivers which flowed across the Coastal Plain in meandering courses, probably during Pliocene time. They have never been mapped in detail and have been disregarded in the preparation of the accompanying sketch map.

Line 11.—This line marks the coastward limit of the outcrop of formations older than Pleistocene. Between this line and the coast only deposits of Pleistocene and Recent ages appear above sea level. This does not mean that these younger sediments are wanting on the landward side of the line, for on the contrary relatively thin terrace deposits of both marine and fluvialile

origin blanket the Tertiary and Cretaceous formations in extensive areas, in places extending back to and even beyond the inner edge of the Coastal Plain. The most widespread development of marine terrace deposits is in the Atlantic Coastal Plain and in Florida, and these record transgressions of the sea inland across the Coastal Plain in Pleistocene time. The most extensive sheets of alluvial terrace deposits occur in the valley of Mississippi River from the head of the Embayment to the Gulf, but terraced areas of lesser width occur in the valleys of all the larger streams crossing the Coastal Plain

STRUCTURE

In general the strata composing the Coastal Plain lie in a gentle monoclinical attitude. They have been tilted seaward and, recalling the attenuated form of the cross-section of the sediments (fig. 1), the tilting was relatively slight, the dip rarely amounting to one degree, generally less than half and often less than a quarter of a degree, except in local structures. Slight as was the tilting it did not take place all at once but from time to time. In each tilting movement there was probably an axis of revolution parallel to the coast west of which the movement was upward and east of which it was downward. In general, but with certain exceptions, this axis advanced coastward with each successive tilting movement, and in this way formations that were laid down in the sea were later raised to various altitudes above the sea, reaching a maximum of 1,000 feet or more. Decrease of load in the area of denudation, and increase of load in the area of deposition have probably been the primary causes of the tilting, except in the New England area where the load of the Pleistocene ice doubtless was a major factor in completely submerging the Coastal Plain. Attention has already been called to the broad differential warping with axes at right angles to the trend of the Coastal Plain, which has resulted in the lobe-like overlapping of younger formations upon older. The approximate position of the axes of the folds in the principal areas of downwarping and upwarping are shown on the map. Where the transverse folding has taken place at different times the axes have not always been in exactly the same position. For example in the area of downwarping in eastern Georgia and southwestern South Carolina the axis in Eocene time lay approximately along the valley of Savannah River, as indicated on the map, whereas the axis of the downwarping which affected the same general area in early Miocene time lay farther west, approximately in the valley of Altamaha River. In addition to the general tilting and the broad transverse warping the Coastal Plain has been affected by minor folding and by many faults, ranging in size from short faults of small displacement to faults many miles in length

and several hundred feet displacement. The distribution of these faults is of interest. In the Atlantic Coastal Plain as far south as Georgia, faults are rare and the few that are known are of small displacement. Faults of some magnitude that we do not now suspect may lie concealed beneath some of the younger overlapping formations. The Charleston earthquake may have been caused by a movement along an active fault in the underlying basement rocks, and, if so, the overlying sediments were doubtless involved in the faulting. Charleston is on the north limb of one of the areas of broad downwarping. North of Cape Hatteras the downwarping in late Tertiary and in Quarternary times affected the Coastal Plain more completely than it did south of that point. The evidence for this appears first in the relatively small drowned valleys of eastern North Carolina, next in the more deeply drowned valleys of Chesapeake Bay and Delaware River, and finally in the completely submerged Coastal Plain off the coast of New England.

In Alabama faulting mostly of a small order of magnitude is abundant in the chalk near the top of the Cretaceous and in the basal formations of the Eocene. However, vertical displacements of as much as 300 feet have been reported in Wilcox County and one larger fault, the Jackson fault, over 15 miles long from north to south, and showing a maximum vertical displacement of 450 feet, lies just east of the east end of the Hatchetigbee anticline, the only large well formed anticline known east of Mississippi River in the Coastal Plain. The latter structure trends northwest-southeast in western Alabama about midway of the Coastal Plain from north to south, is 50 miles long by 20 miles wide, and exhibits a maximum uplift of 600 or 700 feet above the normal position of the beds involved in the folding. Some folding of the anticlinal nose and terrace types has been described in the vicinity of Jackson and Vicksburg in Mississippi, and minor faulting and some reversals of dip are also known in the State. The New Madrid earthquake in the northern part of the Mississippi Embayment is believed to have been due to faulting in the underlying basement rocks, and it is reasonable to suppose that these movements caused breaks and displacements in the overlying Coastal Plain sediments.

As we go westward in the Gulf Coastal Plain evidence of former crustal unrest becomes more pronounced. The intensive work of geologists in the past few years in connection with the development of petroleum resources has brought to light a multitude of faults both small and large in southwestern Arkansas, northern Louisiana, and in Texas, especially in the Upper Cretaceous and lower Tertiary forma-

tions. The Balcones fault zone which extends from north of Austin, southwestward to San Antonio, and westward toward the Rio Grande, and which manifests itself in the present topography as well preserved fault scarps, has long been known. The more important vertical displacements along this fault zone range from 500 to 1,000 feet. The latest pronounced movements in this zone are probably of early Pliocene age. There is in the Texas Coastal Plain another zone of faulting, the existence of which was scarcely suspected until a few years ago, when it was discovered as a result of the intensive study of structural conditions carried on in connection with oil developments. This zone is long and narrow and parallels the Balcones fault zone at a distance of 10 to 15 miles, from Uvalde County south of Uvalde, to Travis County east of Austin. North of Travis County no important faults have been discovered along the trend of the zone in Williamson and Milam counties, but from Falls County northward the zone is continued in many pronounced faults, and it is there known as the Mexia-Powell fault zone. In northeastern Texas the zone bends to the eastward and passes out of Texas into southwestern Arkansas. The zone is almost coextensive with the outcrop of the Midway or basal formation of the Eocene, involving, however, the strata of the underlying Cretaceous and the overlying Wilcox divisions. In contrast to the Balcones faults, the faults in this zone are with rare exceptions scarcely discernible at the surface, due to the fact that erosion has obliterated whatever scarps may have been produced by the faulting. This would seem to show that this zone is older than the Balcones zone, many of whose fault scarps still remain well preserved. Although several of the faults of this greatly attenuated zone had previously been recognized, the game of finding them did not begin in earnest until one of them, discovered in drilling the Mexia oil field, was found to provide the essential conditions for the accumulation of oil. The faults are of all lengths up to 25 miles or more, and the displacements range from a few feet to over 600 feet. In general the faults are arranged *en-echelon* along the zone of faulting, though the trend of most of them makes only a small angle with the trend of the zone. Some of the faults lie almost parallel to each other for long distances. The downthrow of most of the faults is to the west or northwest, though some of them are downthrown to the east or southeast, and several pairs of faults are known to form definite grabens. Commercial quantities of oil have been found on the upthrow side of 7 or 8 of the faults whose downthrow is to the west. The Mexia, Powell, Wortham, and Luling fields are the most notable examples.

The faults of the Texas Coastal Plain are by no means confined to the two main zones of faulting just described, for a goodly number of faults, whose systematic arrangement has not as yet been determined, have been recognized in other parts of the area. In addition to the faults there are several well defined anticlinal folds mostly along or near the margin of the Coastal Plain, such as the Preston anticline, the Leonard-Celeste anticlinal nose, and several folds between San Antonio and the Rio Grande. Probably most of the faults and folds are related to structural movements in the underlying basement rocks.

One of the fascinating features of Gulf Coastal Plain geology, fascinating because of the difficulty of explaining it, is the phenomenon of salt domes. The domes, of which 70 or more are known, are scattered over a wide area in Texas and Louisiana. A few manifest themselves clearly at the surface, but many lie completely buried and hidden. They consist of plugs of salt, ranging in diameter from 1 mile to 3 miles or more, driven like nails in a plank, upward through thousands of feet of Coastal Plain sediments, dragging with them, or pushing ahead of them, fragments of deeply buried formations. In one instance a block of Buda limestone, the uppermost of the Comanche Cretaceous formations, was raised from its normal position of over 5,000 feet below the surface to the surface, as shown by the record of a nearby well. The origin of the salt is still a matter of speculation, though most geologists believe it has been squeezed upward through points of structural weakness, by the weight of surrounding strata, from deeply buried masses of salt of Permian or perhaps of Trinity Cretaceous age. Wells have been drilled to depths of more than a mile in the salt and no well has completely penetrated it. The salt domes of southeastern Texas and southern Louisiana are of particular economic interest because of the occurrence of oil and gas in the sediments surrounding and overlying them.

The increase in structural complexity so noticeable in passing westward in the Gulf Coastal Plain becomes far more pronounced beyond the international boundary in Mexico. Comparable to the Balcones fault zone in its geologic relations is the great zone of faults along the eastern front of the Mesa Central which stands 2,000 to 7,000 feet or more above sea level. In the latter zone, as in the former, the strata of the Upper Cretaceous are downthrown on the east against upthrown limestones of the Lower Cretaceous on the west. But whereas the vertical displacements in the former may be measured in hundreds of feet, in the latter they amount to thousands of feet. In the Balcones zone, small erosion remnants of Upper Cretaceous strata still remain

in places on the Edwards Plateau near its southern margin some 1,100 feet or more above sea level, but in Mexico, notably in the State of San Luis Potosí, great masses of Upper Cretaceous strata have been raised 4,000 feet or more above sea level. The great tract of relatively low country, sometimes referred to as the Huasteca region, which lies between the foot of the eastern front of the Mesa Central and the Gulf Coast, is comparable to the Texas Coastal Plain in that it is composed of Cretaceous and Tertiary sedimentary rocks of the same age and origin, and some of the low-lying country along the coast, and in places extending for considerable distances back from the coast, may rightly be classed as Coastal Plain. But in contrast to the Texas Coastal Plain a large part of this area has been subjected to pronounced folding and faulting, and many hills and ridges and several mountains of no mean size rise above the general lowland. Among the latter may be mentioned the San Carlos, the Tamaulipas, and the Otontepec Mountains. There is also one long fault block mountain range which in early and middle Eocene time stood well above sea level, but which later sank far below sea level and is now completely buried under some 2,000 feet of later Tertiary sediments. This is the great South Fields structure, the Golden Lane, from which prodigious quantities of oil have been recovered. Intrusions of igneous rock, in the form of dikes and larger masses, are also common in many parts of this area. The several greatly elongated structural features, such as the Balcones fault zone, the long line of faulting of which the Mexia-Powell fault zone forms a part, the faulted eastern front of the Mesa Central, the line of structures, including the San Carlos and Tamaulipas Mountains, and the buried structure of the south fields in Mexico, all of which roughly parallel the Coast, seem definitely related to the great geosynclinal basin of the Gulf of Mexico. These features of fracture and folding are generally explained as due to overloading and down-sinking in this basin; but down-sinking is by no means the complete explanation of the faulting. Back of the great fault zones, in the Edwards Plateau and the Great Plains, in the Rocky Mountain region, and in the Mesa Central, great masses of sedimentary rocks formed in marine waters below sea level have not gone down, but instead have been subjected to positive upward movements which have raised them from 1,500 to 5,000 feet or more above sea level.

Briefly reviewing the structure, we have in the Atlantic and eastern Gulf Coastal Plain a gentle monocline with all formations from Cretaceous to Recent included in the Coastal Plain itself. In Texas this monocline has been split by the Balcones faulting and part of the

Cretaceous sediments, chiefly Lower Cretaceous, have been raised to form the Edwards Plateau, too high to be classed with the Coastal Plain. In Mexico Cretaceous sediments, both Lower and Upper, have been raised back of a fault zone which may be regarded as analogous to the Balcones fault zone, to altitudes several times higher than the Edwards Plateau, to form part of the plateau of the Mesa Central. In front of this fault zone a great area of Cretaceous and Tertiary sediments comparable in many ways to those of the Texas Coastal Plain have been folded, faulted, and uplifted into minor mountain masses, in such manner as to exclude them from the Coastal Plain.

THE FOSSIL FLORAS AND FAUNAS

The subject of the fossil floras and faunas of the Coastal Plain is too big a one for even summary treatment in this paper. Fossil plants and animals occur well distributed in the sediments, both geographically and geologically. The fossil plants are found in both the shallow marine and non-marine sediments along and adjacent to the old shore lines, and the shifting of the shore lines has provided the conditions for the preservation of plants here and there in the sediments of the several periods from the Cretaceous to the Pleistocene. But the record afforded by fossil plants is very incomplete. Marine invertebrates are much more completely represented than other classes of organisms, because sediments of marine origin greatly predominate over those of non-marine origin, and also because the conditions of marine sedimentation are more favorable for the preservation of fossil remains. The bones and teeth of vertebrates are found fairly well distributed through the formations of the Coastal Plain but, with few exceptions, are fragmental and incomplete, and while of interest as showing the geologic distribution of vertebrates, they have been of little use in solving the finer problems of stratigraphy and correlation.

In general there have been progressive changes in the character and composition of the floras and faunas from early Cretaceous to Recent time. Evolutionary development has been constantly taking place, species, genera, and even great groups of organisms have become extinct, and new forms have occasionally entered the area by migration from other regions. It is on the basis of such changes that the time relationships of the formations are determined from place to place in the Coastal Plain, and on the same basis sediments of the Coastal Plain are correlated more or less successfully with those of other parts of the continent and of the world. One of the chief difficulties met with in determining the age relationships of the formations of the Coastal Plain by means of fossils is the differences in contemporaneous

faunas due to differences in the ecological conditions under which they lived. Many marine species were restricted to rather definite sets of environmental conditions, so that their fossil remains are not found everywhere in beds of the same age. Fortunately, however, there were also a goodly number which were able to adapt themselves to wider variations, and we find their fossil remains in different kinds of sediments of the same age, as for example, in sands, clays, marls, and chalks, and we are thus able to trace fossil zones through different kinds of sediments.

Of the two classes of fossil organisms, plants and invertebrate animals, it can scarcely be denied that the invertebrates afford the more accurate basis for determining time relationships. Some of the conflicting conclusions arrived at by the application of the two classes of criteria may be due to the tendency on the part of invertebrates to respond more promptly and more definitely, in an evolutionary sense, to changing environmental conditions than do plants. Certain it is that the correlations made on the basis of plants are not always in agreement with those determined by the animal evidence. One of the most striking examples of apparent disagreement is that of the flora of the Ripley formation of northern Tennessee, which, as interpreted, is of the age of the Emscherian, or possibly as young as the overlying Campanian of Europe, whereas the evidence afforded by invertebrate fossils indicates that the Emscherian is represented in the Coastal Plain, not by the Ripley, but by the much older Eutaw formation in the eastern Gulf region, and by the Austin chalk in the western Gulf region, both occupying stratigraphically lower positions than the Ripley. The Ripley plant-bearing beds according to the invertebrate evidence should be correlated with either the uppermost Campanian or with the Maestrichtian, both of which zones are much younger than the Emscherian. This is not intended to belittle the importance of fossil plants in stratigraphy, for the evidence afforded by plants is by no means always in disagreement with that afforded by invertebrates. Fossil plants are especially valuable in correlating irregularly-bedded shallow-water sediments in which invertebrates are rare or wanting.

The record of the organisms that lived in the Coastal Plain during Cretaceous and later time is incomplete even in the marine sediments, for some forms do not lend themselves to preservation, conditions for preservation are less favorable in some kinds of sediments than in others, and there are gaps in the record marking the times when the sea retreated and land conditions prevailed. These gaps are the unconformities, some of which have already been mentioned, and the

more intensive studies of the past twenty years have shown that there are many more of these unconformities than was formerly suspected. The fossil faunas in the sediments above the unconformities are nearly always different from those in the sediments below, and the magnitude of the differences may, with certain limitations, be taken as a measure of the time represented by the unconformities. Any given unconformity should extend coastward into the buried sediments as far as the strand line retreated at the time the unconformity was formed. Beyond that line there should be no break in the succession. Therefore the farther seaward one goes the more complete should be the succession of sediments. Among the many unconformities that have already been recognized in the sediments of the Coastal Plain, there is one which is of preeminent importance. This is the unconformity which separates the Cretaceous from the Eocene. The strand line may have retreated as far as the edge of the Continental Shelf itself. The time represented is believed to have been of great duration. During this time some important changes took place in the character of the organisms inhabiting the sea. Of mollusks, for example, not a single species is known with certainty to have survived from Cretaceous to Eocene time. Although many Cretaceous molluscan genera are represented in the Eocene by new species, descendants of the earlier species, a long list of genera that became extinct at the end of the Cretaceous may be enumerated, and among these may be mentioned one whole order, the *Ammonoidea*, represented by numerous genera. This great unconformity is not confined to our Coastal Plain, nor even to our continent, but appears to be almost world-wide, at least so far as marine sedimentation is concerned, and constitutes an important gap in the record of the marine life of the earth.

CLIMATE

In general the climatic conditions along the Atlantic and Gulf Coastal Plain during Cretaceous and most of Tertiary time, were mild, that is warm temperate to subtropical, and there was no sharp separation into climatic zones. Evidence for close approximation to uniformity in temperature and other living conditions throughout the Coastal Plain in Upper Cretaceous time is clear and positive. This evidence is afforded by the relatively large number of molluscan species that were able to range throughout the area during any given epoch. Emphasis should, however, be placed on the fact that there are also a large number of other species that were not so cosmopolitan in their range. Notwithstanding the close approach to uniformity there were

evidently conditions, probably both climatic and environmental, that limited the geographic range of many of the species. The waters of the Gulf were certainly a little warmer and more tropical than those of the Atlantic during Cretaceous, Eocene, Oligocene, and lower Miocene time, as is shown by the great accumulations of chalk and limestone in the Gulf, and by certain of the fossil organisms. The Chamacea and Rudistacea, for example, which were fairly common in the waters of both of the Lower and Upper Cretaceous in the Gulf, apparently did not venture farther north than Alabama; the larger foraminifera which are abundant in parts of the Eocene and Oligocene, ranged only as far north as the southernmost part of South Carolina,¹ and the molluscan faunas of the Tertiary as high as the lower Miocene contain many tropical elements which did not range far northward along the Atlantic coast. Toward the latter part of Tertiary time a decided climatic change took place along the Atlantic border, as indicated by the cooler water faunas of the Chesapeake, or upper Miocene, which ranged as far south as northern Florida. This may be regarded as foreshadowing the still colder climate of the Pleistocene. The entire Atlantic and Gulf Coastal Plain undoubtedly felt the chill of the Pleistocene glaciers, most in the north, least in the south, but the only places where the ice sheet touched the Coastal Plain were along the southern coast and islands of New England, on Long Island, and in northern New Jersey.

PROBLEMS OF COASTAL PLAIN GEOLOGY

The distribution of the geological formations throughout most of the Coastal Plain has been determined with sufficient accuracy for representation on maps of 1:1,000,000, or even 1:500,000 scale. Comparatively small parts of the area have, however, been mapped in sufficient detail to satisfy the standards of the folio publications of the Geological Survey. Great progress has been made in determining the stratigraphic relationships of the formations, but in every Coastal Plain state there are still unsolved problems in stratigraphy which call for detailed field investigations and systematic studies of the fossil faunas and floras. Hundreds of species still remain to be described, and much is yet to be learned about the environmental conditions under which the faunas and floras lived, and the causes of their changes, migrations, and extinctions.

The remarkable progress that has been made in the past few years in the discovery of structural features in the Gulf Coastal Plain, where the strata had always been supposed to lie mainly in simple monoclinical attitude, may be taken as a prophesy of the discovery of many more

¹ Oral communication from Dr. Wythe Cooke.

such features as intensive search for them proceeds. Many of these features developed in the older formation are completely concealed by overlapping younger formations and can only be recognized by means of well data, and even the structural features which lie at the surface are in places so effectually obscured by the similarity of materials composing adjacent formations of different ages, and by deep weathering and deep soils, that they can only be discovered by detailed and painstaking study. There is need for more definite criteria for determining the origin of different kinds of marine and non-marine sediments. Were they deposited on alluvial plains bordering the coast; were they deposited off the mouths of rivers, and how far off; or were they drifted along shore for greater or less distances before coming to their final resting place on the ocean bottom? Light-colored irregularly bedded sands and clays, such as the Tuscaloosa and Wilcox formations, are not uncommonly assigned to continental origin, yet some such formations were certainly laid down in whole or in part in shallow lagoons, bays, and even in the shallow waters of the sea itself. To what extent are the sediments made up of material derived by chemical precipitation from sea water? In short, the mechanical, chemical, and biological processes involved in the formation of sediments are so far from being completely known that they present fascinating fields of research to future investigators. There is yet much to be learned about the changes in sea level, the warping of the land, the consequent transgressions and recessions of the sea, and the unconformities in the sediments which record these movements; it is safe to predict that many more unconformities will be found in the sediments of the Coastal Plain than are now known. There are interesting problems relating to the origin of the extensive blankets of surficial deposits that cover so much of the Coastal Plain, problems that call for years of intensive study, for there are many divergent opinions about them. There are many economic problems in connection with the non-metallic mineral resources of the Coastal Plain, for the area abounds in raw materials that will some day be developed far more extensively than they are at present—gravel, sand, clay, marl, chalk, bauxite, peat, lignite, and ground waters, not to mention the vast amounts of petroleum and natural gas which doubtless still remain to be discovered in the Gulf Coastal Plain. The discoveries of the past 15 years have shown that, with future more intensive studies, many new and interesting features of structure, stratigraphy, lithology, and paleontology, and many additional raw materials of economic value, are certain to be discovered, so that extensive as have been the investigations of the past, the Coastal Plain still remains an attractive field for geologic, paleontologic, and economic research.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 16

NOVEMBER 3, 1926

No. 18

BOTANY.—*The Costa Rican Species of Ilex.*¹ PAUL C. STANDLEY,
U. S. National Museum.

No representative of the genus *Ilex* (holly) had been reported from Central America until 1925, when I published in this JOURNAL² descriptions of three new species which I had collected in Costa Rica in 1924. During the Costa Rican trip of that year the genus was not noticed until nearly the end of the season, consequently few specimens were collected. It seemed remarkable, however, that a genus represented by three species should not have been detected by some of the numerous botanists who had visited that country.

During the winter of 1925-26 I spent several months more in Costa Rica, and it now seems even more remarkable that the genus was not observed there earlier. Special attention was given this season to study of the genus, with the result that shrubs and trees of *Ilex* were found to be plentiful nearly everywhere in the mountains of central Costa Rica, and in some localities probably 30 per cent of the shrubbery consisted of plants of this genus. Individuals with flowers or fruit are comparatively scarce, and it may be on this account that the group has been overlooked by most collectors.

More than 30 numbers of *Ilex* were collected in Costa Rica this season. Study of them indicates that they represent six species, three of which are described here as new. The following key indicates the relationships of the Costa Rican species, which are the only members of their family known from Central America. It is probable that the genus may be found also in the mountains of western Panama.

¹ Published by permission of the Secretary of the Smithsonian Institution. Received Aug. 3, 1926.

² 15: 476-477. 1925.

KEY TO SPECIES

Leaves rounded or very obtuse at apex, crenate.

Leaves coarsely and conspicuously punctate beneath, not emarginate.

1. *I. vulcanicola*.

Leaves not punctate beneath, usually emarginate at apex 2. *I. tristis*.

Leaves acute or acuminate, entire, crenate-serrate, or appressed-serrate.

Branchlets densely and finely pubescent. Leaves appressed-serrate.

3. *I. pallida*.

Branchlets glabrous.

Leaves entire 4. *I. valerii*.

Leaves crenate-serrate.

Leaf blades elliptic, coarsely crenate-serrate; calyx lobes in fruit acutish. 5. *I. lamprophylla*.

Leaf blades oblong to oblong-elliptic, remotely crenate-serrate with appressed teeth, calyx lobes in fruit broadly rounded.

6. *I. carpintera*.

1. *ILEX VULCANICOLA* Standl. Journ. Washington Acad. Sci. 15: 477. 1925.

The type was collected at Las Nubes. The following additional collections, at altitudes of 2,000 to 2,400 meters, may be reported: Cerro de las Caricias, Province of Heredia, *Standley & Valerio* 52021, 52197, 52256, 52291. The type collection was described as an epiphytic shrub, and it is not improbable that this species may be at times an epiphyte. Usually it is a shrub of 1.5 to 3 meters, growing in wet forest. The leaves are pale green and 1.5 to 5 cm. long. On young plants they are often obovate-oblong, and much narrower than on mature plants.

2. *Ilex tristis* Standl., sp. nov.

Shrub or tree, 3-12 meters high, the young twigs stout and densely leafy, often sparsely hirtellous, petioles stout, 3-4 mm. long, glabrous; leaf blades broadly elliptic or obovate-elliptic, 2.5-4 cm. long, 2-3 cm. wide, broadly rounded and emarginate at apex, rounded or very obtuse at base, coriaceous, coarsely crenate with about 7 crenations on each side, dark green above, paler beneath, glabrous, the costa and lateral nerves prominent beneath; flowers and fruit unknown.

Type in the U. S. National Herbarium, no. 1,251,406, collected in wet forest on Cerro de las Vueltas, Provincia de San José, Costa Rica, altitude 3,000 meters, Dec. 29, 1925, by Paul C. Standley and Juvenal Valerio (no. 43670).

No. 43578, from the same locality, also belongs to this species. It is probable that the following additional collections are referable here: Laguna de la Chonta, Provincia de San José, alt. 2,100 meters, *Standley* 42169. Near Finca La Cima, north of El Copey, Provincia de San José, alt. 2,400 meters, *Standley* 42608. Both these collections were taken from immature shrubs, with foliage more luxuriant than on mature trees, some of the leaves being as much as 8 cm. long.

Ilex tristis is a common tree in the dense, cold, wet forest bordering the paramos about the summit of Cerro de las Vueltas.

3. *Ilex pallida* Standl., sp. nov.

Shrub 1.5-3 meters high, the branchlets grayish, densely puberulent or short-pubescent, densely leafy, petioles stout, 5-7 mm. long, sparsely puber-

ulent; leaf blades oblong-elliptic or elliptic, 4-9 cm. long, 1.7-4 cm. wide, acuminate, often abruptly so, at base obtuse, coriaceous, dark green (pale green and not blackening when dried), remotely appressed-serrate or sub-entire (teeth about 9 on each side, sometimes as many as 18), glabrous in age but when very young sparsely pubescent above along the costa; staminate flowers 4-parted, borne in 2 or 3-flowered, solitary or geminate, axillary umbels; peduncles 5-7 mm. long, glabrous, the pedicels about 3 mm. long; calyx 1.5 mm. broad, the lobes broadly rounded; petals white.

Type in the U. S. National Herbarium, no. 1,251,651, collected on Cerros de Zurquí, northeast of San Isidro, Provincia de Heredia, Costa Rica, altitude about 2,300 meters, March 3, 1926, by Paul C. Standley and Juvenal Valerio (no. 50008).

The following sterile specimens also belong to this species: Near Finca La Cima, north of El Copey, Provincia de San José, alt. 2,400 meters, *Standley* 42729. Cerro de las Vueltas, Provincia de San José, alt. 3,000 meters, *Standley & Valerio* 43753.

In general appearance *I. pallida* is much like *I. lamprophylla*, but the leaves do not blacken in drying as in that species, the leaves of which are coarsely crenate-serrate. The densely pubescent branches of *I. pallida* distinguish it from all other Costa Rican species.

4. *Ilex valerii* Standl., sp. nov.

Tree 4.5 meters high, glabrous throughout; branchlets densely leafy; petioles stout or slender, 1-2.5 cm. long, reddish; leaf blades elliptic-oblong to broadly lance-oblong or elliptic, 5-8.5 cm. long, 3-4 cm. wide, rather abruptly acute or acuminate, at base broadly rounded and often short-decurrent, coriaceous, entire, blackening when dried, not punctate beneath; inflorescences solitary, umbelliform, 3 to 6-flowered, the peduncles 1.8-2.5 cm. long, the pedicels 2-3 mm. long, calyx green, 3 mm. broad, the 4 lobes ovate-deltoid, acutish; petals 4, white, 3-5 mm. long.

Type in the U. S. National Herbarium, no. 1,251,513, collected on the Cerros de Zurquí, northeast of San Isidro, Provincia de Heredia, Costa Rica, altitude about 2,300 meters, March 3, 1926, by Paul C. Standley and Juvenal Valerio (no. 50582).

Ilex valerii is named for Prof. Juvenal Valerio, in whose company it was collected. Prof. Valerio, an enthusiastic student of the Costa Rican flora, accompanied me nearly all the time that I spent in Costa Rica this year. To him I am deeply indebted for unstinted assistance, and for many attentions which contributed largely to the success of this season's work.

This species is very distinct from all others known from Costa Rica, in its long-petioled entire leaves and long-pedunculate inflorescences.

5. *Ilex lamprophylla* Standl. Journ. Washington Acad. Sci. 15: 476. 1925.

The type was collected at La Estrella, Province of Cartago. The following additional collections, at altitudes of 1,400 to 2,400 meters, may be reported: Cerro de las Caricias, Provincia de Heredia, *Standley & Valerio* 52012, 52200, 52273, 52260. Cerro de las Lajas, Provincia de Heredia, *Standley & Valerio* 51539. Yerba Buena, Provincia de Heredia, *Standley & Valerio* 49860, 49816, 49709. Fraijanes, Provincia de Alajuela, *Standley & Torres* 47443,

47423. El Muñeco, Provincia de Cartago, *Standley & Torres* 51332, 51275, 51177.

This is the most common Costa Rican species of *Ilex*, a shrub or tree of 2.5 to 9 meters, with smooth bark, dark green leaves, and greenish white flowers. It grows always in wet forest.

6. *ILEX* CARPINTERAE Standl Journ. Washington Acad. Sci. 15: 477. 1925.

The type was collected on Cerro de la Carpintera, Province of Cartago. The following new collections, at 1,400 to 2,400 meters, may be reported: Cerros de Zurquí, Provincia de Heredia, *Standley & Valerio* 50597. El Muñeco, Provincia de Cartago, *Standley & Torres* 50881, 50918, 50926.

This species is very close to *I. lamprophylla*, and doubtfully distinct. More material will be necessary in order to determine its status. It is a shrub or tree of 2 to 6 meters, with dark green, usually lustrous leaves.

BOTANY.—*Notes on the Genus Sanchezia*.¹ E. C. LEONARD, U. S. National Museum. (Communicated by E. P. KILLIP.)

Sanchezia, a genus of the family *Acanthaceae*, tribe *Ruellieae*, was briefly described² by Ruiz and Pavón in 1794, and four years later was formally published by these authors,³ two species, *S. ovata*, the type, and *S. oblonga* being described. From that time on, no further study of this interesting genus seems to have been made until 1847, when it was redescribed by Nees in Martius' *Flora Brasiliensis*⁴ under the name *Ancylogyne*. Nees proposed two species, *A. munita* and *A. macrocnemis*; the latter proves to be identical with *S. oblonga* Ruiz & Pavón. In his treatise upon the family *Acanthaceae* in DeCandolle's *Prodromus*,⁵ published the same year, Nees adds *A. peruviana* and *A. capitata*. Hooker in 1866 re-established⁶ the old generic name, *Sanchezia*, and added the species *S. nobilis*. The only recent attempt to bring together all the members of this genus is that by Lindau,⁷ who published a key which included ten species.

The genus was named for José Sánchez, a professor of botany at Cádiz. It consists of shrubby or herbaceous plants with large firm leaves, and attractive, bright yellow or purple, sessile flowers in spikes or racemes. The most reliable characters by which the genus may be

¹ Published by permission of the Secretary of the Smithsonian Institution. Received September 23, 1926.

² Fl. Peruv. Chil. Prodr. 5. pl. 39. 1794.

³ Fl. Peruv. Chil. 1: 7. pl. 8, f. c, b. 1798.

⁴ Mart. Fl. Bras. 9: 63. 1847.

⁵ DC Prodr. 11: 221. 1847.

⁶ In Curtis' Bot. Mag. 92: pl. 5594. 1866.

⁷ Bull. Herb. Boiss. II. 4: 315. 1904.

recognized are found in the flowers; the corolla is slender and nearly regular with suborbicular, entire or emarginate lobes; the two stamens, usually exserted, are accompanied by a pair of staminodes.

Natives of tropical America, these plants are confined to the wet forests of the northern Andes, but, being both attractive and adaptable to cultivation, they have reached regions far removed from their natural haunts. Collections have been seen from Costa Rica, Cuba, Java, Siam, and Amboina.

Nineteen species are described in the present paper, and there is reason to believe that many more will be discovered when the rich fields of the tropical Andes have been more thoroughly explored.

KEY TO THE SPECIES

- Bracts large, conspicuous, ovate, longer than the bractlets or the sepals, inclosing the flowers in a cuplike involucre.
- Leaves pubescent 1. *S. ovata*.
- Leaves glabrous.
- Corolla 3 cm. long or less; stamens slightly exserted . . . 2. *S. oblonga*.
- Corolla 4 cm. long or more; stamens distinctly exserted.
- Staminodes 2 mm. long 3. *S. munita*.
- Staminodes 4 mm. long or longer.
- Corolla densely pubescent with straight silky appressed hairs . . . 4. *S. sericea*.
- Corolla glabrous or sparsely pubescent with minute curved hairs.
- Corolla pubescent, yellow or purple.
- Flowers yellow, leaf blades finely undulate-dentate . . . 5. *S. macbridei*.
- Flowers purple; leaf blades coarsely undulate-dentate . . . 6. *S. peruviana*.
- Corolla glabrous, yellow.
- Bracts connate at least to middle.
- Lateral nerves 15 to 17 on either side of the midrib; corolla lobes 5 mm. long . . . 7. *S. cyathibracteata*.
- Lateral nerves 9 to 12 on either side of the midrib; corolla lobes 3 mm. long . . . 8. *S. pennellii*.
- Bracts not connate.
- Leaf blades rounded at base; petiole slender; corolla tube 4 to 6 mm. broad 9. *S. stenantha*.
- Leaf blades gradually narrowed to a winged petiole; corolla tube 8 to 9 mm. broad.
- Staminodes short, about 5 mm. long . . . 10. *S. nobilis*.
- Staminodes about 2.5 cm. long . . . 11. *S. speciosa*.
- Bracts small, ovate or oblong, usually shorter than bractlets or sepals or, if much longer, linear-attenuate, not inclosing the flowers in a conspicuous cuplike involucre.
- Inflorescence capitate 12. *S. capitata*.

Inflorescence spicate or paniculate

Bracts filiform, equaling or larger than the flowers . . 13. *S. filamentosa*.

Bracts ovate or oblong, much shorter than the flowers.

Staminodes very short, about 2 mm. long, inflorescence spicate

3. *S. munita*.

Staminodes 1 cm. long or more; inflorescence paniculate (sometimes spicate in no. 17).

Flowers red or purplish

Corolla 3 cm. long; stamens included. . . 14. *S. parviflora*.

Corolla 4 cm. long or more; stamens exserted.

Calyx lobes oblong, obtuse 15. *S. loranthifolia*.

Calyx lobes lanceolate, acute

Corolla 5 cm. long; inflorescence a large elongate branched panicle 16. *S. longifolia*.

Corolla 4 cm. long, inflorescence very small, a spike or a sparingly branched panicle . . . 17. *S. sprucei*

Flowers yellow.

Corolla 5 to 5.5 cm. long; stamens exserted 5 cm. beyond the corolla tube; lateral veins 12 to 14 on each side of the midrib . . . 18. *S. parvibracteata*.

Corolla 4.5 cm. long; stamens slightly exserted; lateral veins 9 to 10 on each side of the midrib . . . 19. *S. ecuadorensis*.

1. *SANCHEZIA OVATA* Ruiz & Pavón, Fl. Peruv. Chil. 1: 7. pl. 8, f. c. 1798.

Sanchezia glabra Pers. Syn. Pl. 1: 24. 1805.

A herbaceous plant with glabrous yellow flowers and ovate entire pubescent leaves, reported by Ruiz and Pavón from Cuchero, Pozuzo, and Pillao in the vicinity of Chachauassi, Peru.

2. *SANCHEZIA OBLONGA* Ruiz & Pavón, Fl. Peruv. Chil. 1: 7. pl. 8, f. b. 1798.

Sanchezia hirsuta Pers. Syn. Pl. 1: 24. 1805.

Ancylogyne macrocnemus Nees in Mart. Fl. Bras. 9⁷: 63. pl. 7. 1849.

A herbaceous plant with oblong-lanceolate glabrous leaves and pubescent yellow flowers, reported by Ruiz and Pavón from the same localities as the preceding.

3. *SANCHEZIA MUNITA* (Nees) Planch. Fl. Serr. Jard. 23: 257. 1883.

Ancylogyne munita Nees in Mart. Fl. Bras. 9⁷: 63. pl. 7. 1847.

Type collected by Martius in woods along the Madeira River, Province of Rio Negro, Brazil.

An erect shrub about one meter high, with red flowers.

4. *Sanchezia sericea* Leonard, sp. nov.

Plant shrubby, 1.5 meters high; stems quadrangular, glabrous; leaves oblong-obovate, 15 to 30 cm. long, 7 to 11 cm. wide, rather abruptly narrowed at apex to an acuminate tip, gradually narrowed from below the middle to a short winged petiole, distinctly undulate-dentate, both surfaces glabrous and bearing numerous cystoliths 0.5 to 0.75 mm. long, the lateral veins 14 or 15 on each side of the midrib; inflorescence terminal, simple, equaling or slightly

exceeding the upper pair of leaves, the rachis glabrous or slightly puberulent, the flowers 6 or more, sessile, crowded in the axils of the bracts and forming fascicles 2 to 5 cm. wide; bracts ovate, up to 5 cm. long, 2.5 to 3 cm. broad (the immature smaller), dark red, glabrous, bearing cystoliths; bractlets oblong-ovate, 3 to 4 cm. long, 1 to 1.5 cm. wide, obtuse, pubescent; sepals narrowly obovate, 2.5 to 2.8 cm. long, the 2 outer 5 to 6 mm. broad, the 3 inner 3 to 4.5 mm. broad, corolla pale yellow, the tube 5 cm. long, 7 to 8 mm. wide at throat, gradually narrowed from middle to 3 mm. at base, silky-pubescent without, the lobes 4 mm. long, 2 mm. wide, emarginate; stamens 4 to 4.5 cm. long, attached to the corolla tube about 4 mm. above the base, slightly exserted, staminodes 4 to 5 mm. long; style 4 to 4.5 cm. long, glabrous; ovary 4 mm. long; fruit not seen.

Type in the U. S. National Herbarium, no. 1,196,524, collected on the moist banks of the Pastaza River between Baños and Cashuroo, Province of Tungurahua, Ecuador, altitude 1,300 to 1,800 meters, September 25, 1923, by A. S. Hitchcock (no. 21801).

Sanchezia sericea differs from other species of this genus in the large, strongly undulate-dentate leaves and densely silky-pubescent corolla.

5. *Sanchezia macbridei* Leonard, sp. nov.

Herbaceous (?), about 1.5 meters high; stem glabrous, quadrangular; leaves elliptic-oblong, 20 to 30 cm. long, 8 to 12 cm. wide (the lowermost probably larger), abruptly acuminate at apex, narrowed to a short winged petiole with a somewhat clasping base, glabrous, entire or finely undulate-dentate, the cystoliths scattered, the lateral veins 14 to 18 on each side of the midrib; inflorescence spicate, or occasionally with a few branches, equaling or slightly shorter than the upper pair of leaves, the internodes 2 to 9 cm. long, the flowers 10 or more, clustered in the axils of the bracts, bracts ovate, 3 to 5 cm. long, 3 cm. or less broad at base, the lower abruptly long-acuminate, the upper obtuse at apex, red, glabrous, bearing cystoliths, bractlets oblong, 2.5 cm. long, about 1 cm. broad, obtuse at apex; sepals ligulate-obovate, rounded at apex, the 3 outer 2 to 2.5 cm. long, 3 to 6 mm. broad, the 2 inner 1.5 to 1.8 cm. long, 2 to 4 mm. broad; corolla yellow, the tube 5 cm. long, finely pubescent without, the lobes 4 to 5 mm. long, 2.5 mm. broad, rounded at apex; stamens inserted on the corolla tube about 5 mm. above the base, the filaments 4.5 cm. long, exserted 5 mm. beyond the throat of the corolla, sparingly pilose, staminodes 1.5 to 1.8 cm. long; style 6 cm. long, pubescent toward the base; fruit not seen.

Type in the herbarium of the Field Museum of Natural History, no. 536099, collected on the edge of a sunny motafia, at the mouth of the Chinchao River, Pampayacu, Peru, altitude about 1,200 meters, July, 1923 by J. F. Macbride (no. 5056).

From dried specimens this plant superficially resembles *S. peruviana* (DC.) Rusby, but, when fresh, it is readily distinguished by its larger yellow, not red, flowers.

6. *SANCHEZIA PERUVIANA* (DC.) Rusby, Mem. Torrey Club 6: 103. 1896.

Ancylogyne peruviana DC. Prodr. 11: 222. 1847.

Type collected by Matthews (no. 1221) at Scauija, Peru.

Specimens examined:

PERU: Pozuzo, J. F. Macbride 4665 (N, F).⁵

BOLIVIA: San Carlos, Mapiri, Buchtien 1403 (N, Y); Bang 1473 (N, G), 2367 (N, G).

JAVA: Cultivated in the Buitenzorg Botanical Garden, 237 (N).

SIAM: Bangkok, Zimmermann 50 (N).

A shrub, often cultivated for its showy purple flowers.

7. *SANCHEZIA CYATHIBRACTEATA* Milbr. Notizbl. Bot. Gart. Berlin 9: 267. 1925.

Type collected at the mouth of the Capanahua River, eastern Peru, by Tessmann (no. 3134).

A shrub with glabrous yellow flowers and large red connate bracts. This species is closely related to the following.

8. *Sanchezia pennellii* Leonard, sp. nov.

Low shrub, stem obscurely quadrangular, glabrous; petioles 4 cm. long, glabrous, scarcely winged; leaf blades elliptic to elliptic-obovate, 10 to 30 cm. long, 5 to 13 cm. broad, abruptly narrowed at apex to a blunt tip, gradually narrowed at base, shallowly crenate, both surfaces glabrous and bearing cystoliths 0.5 mm. long, the lateral veins 9 to 12 on each side of the midrib; inflorescence spicate, the flowers 6 to 8, sessile, crowded in the axils of the bracts and forming fascicles 3 to 6 cm. in diameter; bracts 5 cm. long, connate half their length, loosely inclosing the flower clusters, the free portion broadly ovate, 3 to 3.5 cm. wide, rather abruptly narrowed to a blunt apex, orange-red on at least the upper portion, glabrous, bearing cystoliths; bractlets elliptic-obovate, 2.5 cm. long, 1 cm. broad, bearing cystoliths; sepals ligulate-obovate, 10 to 15 mm. long, the 3 outer 3 to 5 mm. broad, the 2 inner 2 to 3 mm. broad, rounded at apex, glabrous; corolla yellow, 4 to 5 cm. long, 6 to 7 mm. broad at throat, gradually narrowed from middle to 2 mm. at base, glabrous, the lobes oblong, 3 mm. broad, rounded and emarginate at apex; stamens attached to the corolla tube 5 mm. above its base, the filaments 4 cm. long, exserted 8 mm. beyond the throat of the corolla, pilose, staminodes 4 to 5 mm. long, style 5.5 cm. long, glabrous; fruit not seen.

Type in the U. S. National Herbarium, no. 1,043,822, collected in a sandy loam forest along the Magdalena River at Vuelta de Acuña, Department of Antioquia, Colombia, altitude 125 to 130 meters, January 14, 1918, by F. W. Pennell (no. 3798).

Additional specimens examined:

PANAMA: Forests around Pinogana, southern Darién, Pittier 6527 (N). Marraganti, Williams 659 (N, Y).

COLOMBIA: Brazo de Moro, on the Magdalena River above Barranca Bermeja, Niemeyer 1 (N). Boca Verde, on the Sinu River, Department of Bolívar, Pennell 4573 (Y, G).

Sanchezia pennellii is closely allied to *S. cyathibracteata* Milbr. and agrees well with the original description of that species except that it has smaller corolla lobes and fewer lateral leaf veins. The five ample specimens cited

⁵ N = U. S. National Museum, Y = Herbarium of the New York Botanical Garden; G = Gray Herbarium; F = Herbarium of the Field Museum of Natural History.

are uniform and show no variation other than in the size of the leaf blades and inflorescence. There is no indication that the leaves bear as many as 15 lateral veins on each side of the midrib or that the corolla lobes reach 5 mm. in length. Further ground for proposing this new species is afforded by its range. All the specimens examined by the writer were collected in the forests of northern Colombia and southern Panama, whereas the type of *S. cyathibracteata* was collected in the wet forests of the Amazon Basin in eastern Peru, two regions with very different floras.

The material in the U. S. National Herbarium was distributed as *S. nobilis* Hook. f., which, although closely related, has distinct bracts and narrower leaves with more broadly winged petioles.

9. *Sanchezia stenantha* Leonard, sp. nov.

A glabrous shrub about 1 meter high; stems quadrangular; petioles slender, 4 to 6 cm. long; leaf blades ovate, 10 to 20 cm. long, 8 to 13 cm. wide (the lower probably larger), abruptly acuminate at apex, rounded at base, undulate, the cystoliths more numerous on the upper surface than on the lower, the lateral veins 9 to 11 on each side of the midrib; inflorescence a terminal interrupted spike, the internodes 3 to 7 cm. long, the flowers 6 or more, crowded in the axils of the bracts; bracts ovate, 3 to 4 cm. long, up to 2.5 cm. broad at base, acute at apex, with few cystoliths; bractlets oblong-obovate, slightly shorter than the bracts, the cystoliths few, sepals equal, narrowly obovate, rounded at apex, the 2 outer 6 to 8 mm. broad, the 3 inner 4 to 5 mm. broad; corolla bright yellow, glabrous, 4.8 cm. long, 4 to 5 mm. broad at base, 6 to 7 mm. wide above middle, narrowed at throat, the lobes oval, 3 mm. long, 3.5 mm. broad, emarginate, reflexed; stamens inserted on the corolla tube 5 mm. above its base, 4 cm. long, exserted 8 to 12 mm. beyond the corolla tube, sparsely pilose; anthers 5 mm. long, pubescent; staminodes 1.3 to 1.4 cm. long; style equaling or slightly longer than the stamens, glabrous, fruit not seen.

Type in the herbarium of the Field Museum of Natural History, no. 535709, collected in a stream at Pozuzo, Peru, altitude about 650 meters, January, 1923, by J. F. Macbride (no. 4634).

This species is a very distinct one, easily recognized by the broad ovate leaf blades with round bases, the slender wingless petiole, and the narrow corolla tube.

10. *SANCHEZIA NOBILIS* Hook. f. in Curtis' Bot. Mag 92: pl. 5594. 1866

The original description was based on material collected by Pearce in Ecuador. Although there is little in this description to differentiate *S. nobilis* from closely related glabrous yellow-flowered species, the accompanying plate discloses a number of important and interesting facts. The branched inflorescence and distinct bracts of the plant pictured in this colored plate contrast sharply with the large spike and connate bracts of *S. pennellii* Leonard and *S. cyathibracteata* Milbr. The resemblance to *S. speciosa* Hook. f. is, however, much closer. In the original description Hooker states that the leaf blades are either oblong-obovate or oblong-lanceolate. The colored plate shows a

plant with leaves strongly oblong-obovate, very different from the oblong-elliptic leaves of *S. speciosa*. Figure 2 in this plate is a longitudinal section of a flower, showing clearly the very short staminodes, scarcely 5 mm. long, which are characteristic of *S. pennellii* and *S. cyathibracteata*, but not like the long slender ones found in *S. speciosa*.

It is interesting to note that this species is not represented in the U. S. National Herbarium, although the majority of the specimens of *Sanchezia* had been determined as *S. nobilis*, and doubtless much of the material referred to *S. nobilis* in other herbaria belongs to other species.

11. *Sanchezia speciosa* Leonard, sp. nov.

Plant shrubby; stem quadrangular; leaves oblong-elliptic, 10 to 25 cm. long, 3 to 7 cm. broad (the lowermost probably larger), tapering to a slender blunt apex, gradually narrowed to a short winged petiole (sometimes rather abruptly narrowed at base), both surfaces glabrous and bearing curved cystoliths 0.5 mm. long, undulate or shallowly undulate-dentate, the lateral veins 9 to 12 on each side of the midrib, inflorescence an interrupted spike (or with a few short branches), equaling or exceeding the upper pair of leaves, the internodes 1 to 3 cm. long, the flowers 3 or more in the axils of the bracts and forming fascicles 1 to 2 cm. broad, bracts ovate, blunt at apex, glabrous, bearing cystoliths; bractlets about 2 cm. long, 8 mm. broad, obtuse at apex; sepals ligulate, 1.5 to 1.8 cm. long, 3 to 5 mm. wide, rounded at apex; corolla yellow (?), the tube 4 to 5 cm. long, 7 to 8 cm. broad at throat, narrowed below the middle to 3 mm., glabrous, the lobes 3 to 4 mm. long, rounded, emarginate; stamens inserted about 5 mm. above the base of the corolla tube, the filaments 4 to 4.5 cm. long, exserted 5 to 15 mm. beyond the throat of the corolla, sparingly pilose, anthers 5 mm. long, staminodes 2.5 cm. long; style about 5 cm. long, equaling or exceeding the stamens; fruit not seen.

Type in the U. S. National Herbarium, no. 522,243, collected in the Botanical Garden of Havana, Cuba, January, 1905, by A. H. Curtis (no. 622). Another specimen was collected from the same place and probably from the same plant by Van Herinann (no. 2700).

Additional specimen examined:

MARTINIQUE: *Duss* 835 (Y).

Both the type and Van Herinann's no. 2700 had been referred to *S. nobilis*. They differ from this species in having much longer staminodes and narrower, more pointed leaves. The colored plate of *S. nobilis* Hook. f. in Curtis' Magazine shows a plant with obovate leaf blades gradually tapering to a broadly winged base.

The type was collected from a plant grown in cultivation and its native country is unknown. It was probably procured from the Andean region in Peru or Ecuador, the center of distribution for the genus *Sanchezia*.

12. *SANCHEZIA CAPITATA* (Nees) Lindau, Bull. Herb. Boiss. II. 4: 315. 1904.

Ancylogyne capitata Nees in DC. Prodr. 11: 222. 1847.

Type collected by Matthews (no. 1230) at Pangoa, Peru.

This peculiar capitate-flowered *Sanchezia* has red flowers with long-exserted stamens.

13. *SANCHEZIA FILAMENTOSA* Lindau, Bull. Herb. Boiss. II. 4: 314. 1904.

Type collected by Ernst Ule (no. 6401) near Pong de Canarachi, Province of Loreto, Peru.

A shrub 1 to 3 meters high, producing pubescent purple flowers with long-exserted stamens. It is very distinct from all other species of *Sanchezia* in the long-attenuate bracts, bractlets, and sepals.

14. *Sanchezia parviflora* Leonard, sp. nov.

A glabrous shrub; stem quadrangular; leaves oblong-elliptic, 10 to 25 cm. long, 3 to 6 cm. broad (the lower probably larger), obliquely acuminate at apex, narrowed at base to a short winged petiole, entire or undulate, bearing cystoliths on both surfaces, the lateral veins 10 to 11 on each side of the midrib; inflorescence small, paniculate, 10 to 15 cm. long, the flowers 1 to 3 in the axils of the bracts; bracts oblong to linear-lanceolate, 1 to 2 cm. long, 2 to 3 mm. broad, acuminate; bractlets about 1 cm. long, 4 to 5 mm. wide; sepals oblong-lanceolate, about 2 cm. long, 3 to 5 mm. broad, acute at apex; corolla pale scarlet, the tube 3 cm. long, 6 to 7 cm. broad at throat, narrowed to 3 cm. at base, glabrous or sparsely pubescent without, pubescent at the insertion of stamens within, the lobes oblong, 4 mm. long, 2.5 cm. broad, emarginate; stamens inserted on the corolla tube about 5 mm. above the base, the filaments 2.2 to 2.5 cm. long, included or but slightly exserted, glabrous or sparsely pilose above, densely pubescent below, the anthers 5 mm. long, pubescent; staminodes 6 to 7 mm. long, pubescent below; style 2.5 to 2.7 cm. long, glabrous; fruit not seen.

Type in the U. S. National Herbarium, no. 1,196,194, collected between Santa Rosa and La Chonta, Province of Oro, Ecuador, altitude below 100 meters, August, 1923, by A. S. Hitchcock (no. 21127).

This species is well marked by the small red corolla, small inflorescence, and obliquely tipped leaves. *Sanchezia ovata* Ruiz & Pavón is described as having flowers 3 cm. long, but it has yellow flowers, a spicate inflorescence, and pubescent leaves.

15. *SANCHEZIA LORANTHIFOLIA* Lindau, Bull. Herb. Boiss. II. 4: 314. 1904.

Type collected by Ernst Ule (no. 6820) along the Cumbaso River near San Pedro, Province of Loreto, Peru.

A shrub 1 to 3 meters high with red flowers and long-exserted stamens

16. *SANCHEZIA LONGIFLORA* Hook. f.; Planch. Fl. Serr. Jard. 23: 257. pl. 2460. 1883.

Ancylogyne longiflora Hook. in Curtis' Bot. Mag. 92. pl. 5583. 1866.

This plant was introduced into Europe about 1868 by Pearce, who collected it near Guayaquil, Ecuador. It is very well marked by the "bright vinous-purple" corolla and the lance-subulate sepals.

17. *SANCHEZIA SPRUCEI* Lindau, Bull. Herb. Boiss. 5: 648. 1894.

Type collected near Tarapoto, eastern Peru, by Spruce (no. 4325) Specimen of type collection seen in the Gray Herbarium.

S. sprucei is related to *S. parviflora* Leonard but differs in having smaller leaves, larger flowers, and tomentose stems and sepals.

18. *SANCHEZIA PARVIBRACTEATA* Sprague & Hutchinson, Kew Bull. Misc. Inf. 253. 1908.

Sanchezia sprucei salvadorensis Donn. Smith, Bot. Gaz. 44: 116. 1907.

The original description was made from a plant cultivated at Kew. Its type locality and original collector are not mentioned.

The type of *S. sprucei salvadorensis*, cultivated in the city of San Salvador, Salvador, was collected by Velasco (no. 6985). So closely does the short original description of this plant agree with *S. parvibracteata* that the writer, although he has not seen the type specimen, has reduced it to synonymy.

Sanchezia glaucophylla is a horticultural variety introduced into Europe from Brazil. It was mentioned⁹ in a report of the Russian International Horticultural Exhibition, held in St Petersburg in 1869, and there described as a plant with "large ovate-acuminate leaves, veined with yellow" and with a red line on the midrib. This plant was undoubtedly what is now called *S. parvibracteata*.

A shrub about 1 meter high, commonly cultivated for its large panicle of beautiful yellow flowers and its yellow-veined leaves.

Specimens examined:

GUATEMALA: In garden, Department of Quetzaltenango, *Rojas* 165 (N).

EL SALVADOR: Cultivated in San Salvador, *Standley* 19362 (N, Y, G); *Calderón* 588 (N, G). Cultivated in Santa Clara, Department of Ahuachapán, *Padilla* 173 (N).

JAVA: Cultivated in the Buitenzorg Botanical Garden, *Merrill* in 1902 (N, Y).

AMBOINA: *Robinson* 1787 (N, G).

Cultivated: Botanical Garden of Harvard University in 1874 (G).

19. *SANCHEZIA ECUADORENSIS* Leonard, sp. nov.

Shrub 2 to 3 meters high; stem quadrangular, glabrous; petioles about 2 cm. long, glabrous, winged, connate at base; leaf blades obovate, about 25 cm. long, 8 to 10 cm. wide (the uppermost leaves much smaller, obovate-lanceolate), rounded and abruptly acuminate at apex, gradually narrowed at base, shallowly undulate, both surfaces glabrous and covered with cystoliths 0.5 to 1 mm. long, the lateral veins 10 to 11 on each side of the midrib; inflorescence sparingly branched, the flowers 2 to 4 in the axils of the bracts and forming fascicles 1 to 1.5 cm. wide; bracts obovate, 14 to 16 mm. long, 7 to 8 mm. wide, dark red, glabrous; bractlets similar, 11 to 12 mm. long, 4 to 5 mm. broad; sepals narrowly oblong-obovate, 15 to 20 mm. long, 4 to 7 mm. broad, obtuse at apex, the tip pubescent; corolla yellow, the tube 4 to 4.5 cm. long, 8 mm. wide at throat, narrowing below the middle to 4 mm. at base, minutely pubescent above, glabrous below, the lobes 5 mm. long, 3 mm. wide, emarginate; stamens slightly or not at all exserted, the filaments 16 mm. long, attached to the corolla tube 8 cm. above the base, pilose; staminodes 10 to 13 mm. long, style 4 cm. long, glabrous; fruit not seen.

Type in the U. S. National Herbarium, no. 1,196,543, collected on the banks of the Pastaza River, between Baños and Cashurco, Province of Tungurahua, Ecuador, altitude, 1,300 to 1,800 meters, September 25, 1923, by A. S. Hitchcock (no. 4833).

Sanchezia ecuadorensis is related to *S. loranthifolia* Lindau. It closely resembles that species in many respects but differs in having yellow, not red, flowers and included or very slightly exserted stamens.

⁹ Gard. Chron. 387. 1893.

ETHNOLOGY.—*Notes on the mental assimilation of races.*¹ JOHN R. SWANTON, Smithsonian Institution.

Since physical race mixture may be detected and in some degree weighted by means of measurements and color charts, the question naturally arises whether there are analogous differences of a psychological character which may also be identified. If so, one good test should present itself when individuals of a certain race have been adopted or captured at an early age by those of another and have been brought up wholly immersed in the culture of that other. If there is an actual psychological distinctness between the two, it should be recognized in the adopted or captured individuals as an element unaccountable on the basis of their cultural surroundings. In the course of a somewhat extended reading of miscellaneous works dealing with the Indians of North America the writer has gone over a number of narratives of white children brought up among the natives and during this work it occurred to him to take notes of these cases along with the impressions which the individuals in question made upon those who observed them. In a few cases we have the testimony of the individuals themselves. It must be remembered that no idea can be given of the number of captives who never became reconciled to their new surroundings and who escaped or died, but the general testimony of early writers is that such failure to assimilate seldom occurred in the case of a child provided it was able to endure the hardships of its first years of captivity.

It may be well to begin with the experiences of John D. Hunter, whose *Memoirs*, in spite of the over-polished style into which his editor has cast them, bear upon the whole the stamp of reliability. Hunter himself was a white captive of the class with which we are concerned. Carried away, when a boy, by a band of Kickapoo, he passed temporarily into the hands of a body of Pawnee and then in succession to the Kansa and Osage tribes. While he ultimately returned to live among the whites and, as in many another case, became something of a lion there, it is evident from his narrative that a slight change in the course of events would have resulted in a permanent sojourn with his adopted people.

More important than Hunter's own experience, however, are several cases of white captives mentioned by him in the course of his narrative. Thus, in the band of Kickapoo which originally took him

¹ Received Oct. 1, 1926.

prisoner was a white woman, married to a chief, who, he says, "joined with, and I believe surpassed, the squaws in the extravagance of her exultations and rejoicings on account of the safe return of the warriors with prisoners, scalps, and other trophies obtained from their vanquished foes," i.e., the whites.¹ Farther on we find the following:

I may here observe that I met three or four white children, apparently of my own age, while travelling among the different tribes. They appeared, like myself, to have been at first forced to assume the Indian character and habits; but time and a conformity to custom had nationalized them, and they seemed as happy and contented as though they had descended directly from the Indians, and were in possession of their patrimony. . . . It is a remarkable fact, that white people generally, when brought up among the Indians, become unalterably attached to their customs, and seldom afterwards abandon them. I have known two instances of white persons, who had arrived at manhood, leaving their connections and civilized habits, assuming the Indian, and fulfilling all his duties. These, however, happened among the Cherokee.²

Another white captive, John Tanner, like Hunter, broke away from his adopted people, the Chippewa, long enough to have his memoirs incorporated into a book, but he afterward returned to the forest and Schoolcraft says of him that he had "lost every virtue of the white man, and accumulated every vice of the Indian (!)."³

Among the Indians living near the Wabash in the eighteenth century, Gerard Hopkins, a missionary belonging to the Society of Friends, saw a white girl captive who could only be distinguished from the Indians by her gray eyes.⁴

In the same region, Charles Johnson, himself a captive of the Wyandot, noted two others living like all the rest, and one of them able to use only broken English. The other had been promoted to the rank of a chief.⁵

Isaac McCoy, in his *History of the Baptist Missions*, recounts the case of a white man "by the name of Fish, who had lived with the Shawanoes from a small boy, and was in all respects identified with them, had become a principal chief of a clan who had lived many

¹ *Memoirs of a Captivity among the Indians of North America*, JOHN D. HUNTER. London, 1823, p. 6.

² *Ibid.*, p. 14.

³ *Personal Memoirs of a Residence of Thirty Years with the Indian Tribes* HENRY R. SCHOOLCRAFT Philadelphia, 1851, p. 316.

⁴ *A Mission to the Indians from the Indian Committee of Baltimore Yearly Meeting, to Fort Wayne, in 1804.* GERARD T. HOPKINS, Philadelphia, 1862, p. 64.

⁵ *A Narrative of the Incidents Attending the Capture, Detention, and Ransom of Charles Johnson.* New York, 1827, pp. 61, 67.

years in the State of Missouri, and which was in a good degree civilized."⁷

The Rev. David Jones in "A Journal of Two Visits Made to Some Nations of Indians on the West Side of the River Ohio, in the Years 1772 and 1773," speaks of meeting a white lad, who was a captive, and says, "When I spoke to him [I] was very sorry to see him shake his head and reply, '*Motta keeno toleeh neeknana*,' i.e., I do not understand you, my friend."⁸ He also speaks of two white women among the Indians, one of whom had married a chief. He adds, "These women were captives, and it is likely from childhood, for they have the very actions of Indians."⁹

One of the Gilbert family, Benjamin Gilbert, jun., who had been carried away by the Iroquois, came to be "considered as the king's successor, and entirely freed from restraint, so that he even began to be delighted with his manner of life; and had it not been for the frequent counsel of his fellow captives, he would not have been anxious for a change."¹⁰

Better known than any of the above is the case of Eunice Williams, taken by Iroquois in the massacre at Deerfield, Mass., in 1704. Her father was a minister, and she had been brought up in the strictest principles of Puritanism, but three years after she had been carried off she was unwilling to break with her new life. This refusal was repeated several times, and in 1713 she married a young Indian. In 1740, in company with other Indians, she revisited the scenes of her childhood and repeated the journey twice afterwards, but she had lost her knowledge of English entirely and even refused to sleep in a white man's dwelling.¹¹

Another instance is that of John Slover, who was among the Indians from his eighth to his twentieth year. He says, "At the treaty of Fort Pitt, in the fall preceding what is called Dunmore's War . . . I came in with the Shawanese nation to the treaty, and meeting with some of my [white] relations at that place, was by them solicited to relinquish the life of a savage, which I did with some reluctance, this

⁷ *History of Baptist Indian Missions*. ISAAC MCCOY Washington and New York, 1840, p. 405.

⁸ *A Journal of Two Visits Made to Some Nations of Indians on the West Side of the River Ohio, in the Years 1772 and 1773*. REV. DAVID JONES New York, 1863, pp. 85, 86.

⁹ *Ibid.*, p. 88.

¹⁰ *A Selection of Some of the Most Interesting Narratives of Outrages, Committed by the Indians in their Wars with the White People*. ARCHIBALD LOUDON 2 vols., Carlisle, 1808 (reprinted in 1888), 2: 126.

¹¹ *An Unredeemed Captive*. CLIFTON JOHNSON, 1897, pp. 41-52.

manner of life having become natural to me, inasmuch as I had scarcely known any other."¹²

That there was little natural sympathy between white captives at times, is shown by the experience of John M'Cullough, who was also captured when a boy. He was accused of killing an Indian boy, he says, "which I always denied, but *Queek-queek-co-mooch'-que*, a little white girl (a prisoner), who lived with the family that the deceased belonged to—was like to be the worst evidence against me, she told them that she saw me have the pistol in my hands several times." When M'Cullough was purchased from the Indians by his father, instead of being grateful, he wept bitterly and had to be carried away tied to a horse. Later he escaped and returned to his adopted people. He reports the same of two other white captives.¹³

John Brickell was carried off by some Delawares and lived with them in Ohio for many years. In the narrative of his experiences he commends the Indian method of bringing up children in the highest terms and says "I know I am influenced to good, even at this day, more from what I learned among them, than what I learned among people of my own color." When his Indian father asked him if he would return to the whites or remain with him, he "Was silent a few minutes, in which time it seemed as if I thought of almost everything. I thought of the children I had just left crying; I thought of the Indians I was attached to, and I thought of my people which I remembered; and this latter thought predominated, and I said, 'I will go with my (white) kin.'"¹⁴

In a band of Chippewa living near the Assiniboine River Harmon saw a white captive of whom he says, "this fellow is lost, beyond recovery, for he now speaks no other language, but that of the Indians, among whom he resides, and he had adopted all their manners and customs; and it would now be as difficult to reconcile him to the habits of civilized life, as it would be, were he a real Indian."¹⁵

At a much later date Col. Henry Inman reports the case of a white girl who had been left among the Blackfeet when a baby and who appeared to be no different psychologically from the Indians about her.¹⁶

¹² LUDON, ARCHIBALD. *Op. cit.*, 1: 21

¹³ *Ibid.*, p. 264

¹⁴ *Narrative of John Brickell's Captivity among the Delaware Indians. The American Pioneer*, ed 2 1: 46-48, 54, Cincinnati, 1842.

¹⁵ *A Journal of Voyages and Travels in the Interior of North America, etc.* DANIEL WILLIAMS HARMON. Andover, 1820, p. 141

¹⁶ *Buffalo Jones' Forty Years of Adventure* COL. HENRY INMAN. Topeka, Kans., 1890, pp. 282-286

Fanny Kelly, a captive among the Dakota, tells of another white girl whose family had been destroyed by cholera and who had been found and reared by that tribe. She lived and acted exactly like those who had adopted her. A white boy, cited by Miss Kelly, lived for many years in the same condition but, later, becoming discontented, left them and became an interpreter and trader.¹⁷

Some Americans and a great many Mexicans were carried off by the Comanche, Kiowa, and other tribes of the southern Plains. About the year 1847 Schoolcraft, in speaking of the first mentioned, says: "There are a number of Mexican juvenile prisoners among them. Those I saw were reluctant to being released."¹⁸ A Texan named Nelson Lee, in an account of his captivity among the same Indians, tells of four girl captives who seemed to live and behave exactly like the rest of the Indians.¹⁹ The Rev. J. J. Methvin, a missionary on the southern Plains, narrates the life of a Mexican Kiowa captive named Andele who was finally reclaimed from them and became a missionary. He was taken by them "when a boy, and raised among them, and in ways and habits and dress was scarcely distinguishable from the real Indian." In three years "he had learned many things of the Indian life and had accepted them all." Somewhat later "he took up his time in studying the Indian ways, for he had now come to believe all their superstitions, and engage in their worships. He had caught the spirit of their aspirations, and he hoped to be a great war chief. He thought the Indian idol or 'medicine,' would pity him and help him, and so he cried to it, and often at night he would get up, go to the medicine man, worship, and offer a blanket or bit of property he possessed." At one time he strove to cure a wounded man and he contemplated the purchase of a shield.²⁰

It may very properly be objected that as most Mexicans themselves have Indian blood the testimony of Mexican captives is inconclusive. However, while Andele was among the Kiowa, they had with them also a Texas boy captured at the age of five, adopted, and given the name Tahan, who seems to have been as thoroughly Indianized as any of the Mexicans. "At the time of this outbreak near Anadarko,

¹⁷ *Narrative of my Captivity among the Sioux Indians* FANNY KELLY. Chicago, 1880, pp. 138-141.

¹⁸ *Historical and Statistical Information respecting the History, Condition and Prospects of the Indian Tribes of the United States*, 1: 235. Philadelphia, 1851-67.

¹⁹ *Three Years among the Comanches* NELSON LEE Albany, 1859, pp. 158-9.

²⁰ *Andele, or the Mexican-Kiowa Captive*. Rev. J. J. METHVIN. Louisville, 1899, pp. 40, 77, 99, 105-8.

Tahan was about eighteen years old, and was as complete an Indian in habits, customs, and superstitions, as the most extreme Indian, and was as bitter and cruel in purpose [pursuit?] of bloodshed and plunder." He was captured by soldiers but escaped and returned to the Indians where he was finally killed by a Kiowa chief.²¹ Several other captives are mentioned who, when returned to their friends, "had forgotten their names and every word of English."²² Another writer speaks, indeed, of a Texas boy who was kept by the Comanche for a year and then sold to the Mexicans because he would not adopt Indian ways of living, but this is unusual, and it cannot mean that the boy in question was of exceptionally high mentality because his case is more than offset by that of the Parker children. One of these became a noted Comanche chief, while his sister married in the tribe and became the mother of the famous head chief Quana Parker.²³

Two cases are of particular interest, the first because it is an intimate and lengthy personal narrative, the second because it has received little or no editing and presents a most vivid picture of Indian life from the inside.

The hero of the first narrative was a Mormon boy, Elijah Nicholas Wilson, well known in Utah as "Uncle Nick." He was induced, by the promise of a pinto pony, to run away from home and was adopted by the mother of the noted Shoshoni chief Washakie. He was then twelve years old and lived two full years among the Indians before returning to his own people. During this time he had no desire to leave his new friends, and he became as strongly attached to his Indian mother as if she had been his own. At the same time he was old enough when he left the whites to be able to view his aboriginal associates and their customs with some sort of critical discrimination. Absorption in the new life was by no means complete.²⁴

The second case was that of Herman Lehmann, belonging to a German family settled in Texas. In his eleventh year this boy and his brother were captured by a band of Apache, but, while the brother escaped shortly afterward, he remained with the Indians five years, first among the Apache and later with the Comanche. Unlike Wilson's story, this narrative shows an utter abandonment to the life of the

²¹ *Ibid.*, pp. 118-127.

²² *Ibid.*, p. 133.

²³ *Handbook of American Indians*, Bull. 30, Bur. Amer. Ethnol., article *Quana Parker*; also see work by JONATHAN H. JONES cited below.

²⁴ *Among the Shoshones*. ELIJAH NICHOLAS WILSON. Salt Lake City, 1910.

red man, in which the hero came to share all of the customs and prejudices of his associates, including their profound dislike of white people, and in which he continually took part in raids, even against his own people, and was as little disturbed as his companions at the taking of human life or any sort of atrocity. So great was his devotion to this manner of existence that he was a member of the last band of irreconcilable Comanche brought in through the intervention of Quana Parker. Here are some excerpts from his narrative:

We were all camped down near the southern border of the plains and twelve of us in one party (several other parties left at the same time thus leaving the squaws almost unprotected) came down the San Saba river to where it empties into the Colorado and then crossed over to the Llano river and up it to Llano town collecting horses as we went for we were not traveling for our health. There we came in contact with teamsters, fought them, killed them, scalped them, burned their wagons, drove away their horses and felt happy.

Our scouts reported that the rangers were following us so we scattered out and gave them the dodge. The rangers never caught us but when we reached camps with all our booty we found that all of our women had been killed or captured except ten and all the men but two Indians and a Mexican who had married one of our women and been admitted into the tribe . . .

Just fifteen warriors left and ten women! We bury the dead and follow the soldiers toward Ft. Griffin and somebody steals nearly all of our horses; we fail to recover our women. We return to the plains, steal out the camps of buffalo hunters, kill the men and get their guns, but the soldiers were after us all the time.

One day we met a company of soldiers but were not strong enough to fight them, so we dodged them and went into Sandy Hills and on across to the Pecos and there met more United States troops and we were driven back across the plains. There was no rest nor peace for us poor Indians. We killed meat and prepared for winter, six of us went near Ft. Griffin and stole a nice herd of the horses kept by soldiers and as we came back we passed a ranch and drove eleven more good trained horses into our herd and we reached camps with five choice animals.

We moved further out into the plains and met ten buffalo hunters and had a hard fight; we ran these fellows out of the country. We then hunt, ride bronchos and have a good time. . . .

. . . . We went into Mexico with our gold [obtained from a mine they had discovered] and got all the guns, ammunition and horses we wanted. . . .

We made a treaty with the Mexicans; attended a Mexican dance; drank mescal and cheap whiskey; got into a row and had to leave the country in short order, but the Mexicans offered us peace and protection again if we would locate the gold mine for them but this we would not do, not that we thought the metal so valuable but because we thought more palefaces would come.²¹

²¹ *A Condensed History of the Apache and Comanche Indian Tribes for Amusement and General Knowledge, Prepared from the General Conversation of Herman Lehmann, Willie Lehmann, Mrs. Mina Keyser, Mrs. A. J. Buchmeyer and Others* JONATHAN H. JONES. San Antonio, 1899, pp. 178-179.

After they had been brought into the reservation

One Indian proposed to me that we steal a girl apiece and run away. I went and talked to my old girl that nursed me when her father shot me and she consented to go. We were to meet that night. My chum stole another man's wife, two good horses and other necessities and made good his escape. My girl was true to her promise, stole all the goods she could carry and waited for me until nearly daylight. I started and was nearly to where my girl was when the soldiers who had been secretly watching me made a drive for me. I ran off of a bluff and fell into the river and came near freezing and eventually was driven back to camps and so many soldiers watched me that I had no chance of escape.²⁵

We came on to Ft. Griffin and all these soldiers got on a whiz, stole my money and all went to the "lockup" and a new outfit brought me on but I was allowed to kill game and do pretty much as I pleased but they kept an eye on me all the time. We came on to a big hole of water and there these soldiers caught big bull frogs and fried them in lard—bah! I quit camps! That was a violation of a sacred treaty that we had made years ago with the Caranahuas and therefore against our religion. I would not eat with those soldiers any more; I cut off meat and roasted it on an iron. Frogs and swine, both water or mud animals, too much for me! ²⁷

He was at length brought back to his own people in Texas, but

. . . . I was homesick and was planning, scheming and contriving to run away; I would much rather have gone back on the plains along with the birds, wild animals and Rosanante [his horse] but finally I went in to the table and was just going to sit down when I saw a fine swine ham smoking hot on the table. I kicked over everything in my reach and made for the door but they stopped me and entreated me not to do that way but come and eat . . .

I sat around and smoked cigarettes, one thing I did enjoy was good tobacco; went down to the creek, made a bow and a great many arrows, sang all the time like a Comanche and waged war against the 'hog family.' Whenever a shote came in sight I would kill him, no matter to whom he belonged.

I would saddle up my Comanche pony and go out hunting. Somebody gave me a Winchester and my step-father furnished me with cartridges. Willie [his brother] always went with me to watch me and teach me. I wanted to steal calves but Willie told me that was wrong. I insisted that we take all the horses we saw but Willie would not allow that so I was mad all the time, in fact, nothing pleased me.

When I met children I would give a yell and draw my bow on them just to see them run and that was all the real enjoyment I had

I would kill deer, put them on my pony, ride up to the gate, dismount and leave the horse and deer there. If anybody wanted the deer they had to go skin and clean them, I would not; and somebody had to feed my pony too for I thought work of that kind was for squaws. I was furious if they failed to roast me the short-ribs or tenderloins but my people tried to do everything to please me for several months and I began to learn to behave.²⁸

²⁵ Ibid., p. 187.

²⁷ Ibid., p. 189.

²⁸ Ibid., pp. 191-192.

Of about thirty cases of captivity, fifteen males and fifteen females, three or four of the males became chiefs and three or four of the females chiefs' wives, but the proportion does not appear to be above what might have been expected. It may be added that of about seventy chiefs and noted men in the collection of McKenney and Hall only about one-tenth are known to have had white blood. The percentage warrants no deduction of white superiority.

It is important to notice that the factors tending to prevent assimilation of captors and captured were (1) the physical differences between them and (2) knowledge that there was a difference in origin. I place these in the order of value, for while the first constituted an indelible mark which could be understood by stranger as well as acquaintance, the latter could operate only with a few and would rapidly fall out of memory without the other to keep it alive. Hunter was taunted by the Indian boys on account of his color and he adds: "I also met some [mixed-bloods], whose parents, either on the side of the father or mother, had been white; they sustained the character of brave warriors; but in general no cast, differing from that of the tribe, is held in repute or estimation."

Numerous instances might be cited in confirmation of what Hunter says. In other words, the barriers to complete amalgamation between the Indians and their captives were failure to conform to the physical and cultural type demanded by the former, but whereas it seems to have been possible to bring about complete cultural conformity, equal physical conformity was unattainable. We find the same difficulty when absorption of Indians by whites is in question. As a social being, man, if not admitted to social intercourse in one group will usually ally himself with another. This, rather than racial urge, is, I believe, the explanation of those frequently cited instances in which an individual of some race, Indian or other, has been taken from his people, highly educated and, after an apparent conformity to white ways, returns to his people and throws his civilized acquirements entirely aside. In most cases this means that he has not been accepted by his European associates on equal terms. In others it may be that the returns to his old life merely because circumstances have separated him from his white associates and he has reabsorbed the culture of his own people just as we have seen white people absorb it for the first time when thrown continually in contact with it.

A most incisive statement of this process and a still more sinister result of its failure was given many years ago by some New England missionaries. It runs as follows:

An Indian youth has been taken from his friends and conducted to a new people, whose modes of thinking and living, whose pleasures and pursuits are totally dissimilar to those of his own nation. His new friends profess love to him, and a desire for his improvement in human and divine knowledge, and for his eternal salvation; but at the same time endeavour to make him sensible of his inferiority to themselves. To treat him as an equal would mortify their own pride, and degrade themselves in the view of their neighbours. He is put to school; but his fellow students look on him as a being of an inferior species. He acquires some knowledge, and is taught some ornamental, and perhaps useful accomplishments; but the degrading memorials of his inferiority, which are continually before his eyes, remind him of the manners and habits of his own country, where he was once free and equal to his associates. He sighs to return to his friends; but there he meets with the most bitter mortification. He is neither a white man nor an Indian, as he had no character with us, he has none with them. If he has strength of mind sufficient to renounce all his acquirements, and resume the savage life and manners, he may possibly be again received by his countrymen: but the greater probability is, that he will take refuge from their contempt in the inebriating draught; and when this becomes habitual, he will be guarded from no vice, and secure from no crime.²⁹

While the cases brought together in this paper tell much the same story, the number should be very much increased, similar studies of white captives among other peoples of the world should be made, and the whole checked by reciprocal cases of captives from the various primitive races held by whites.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

405TH MEETING

The 405th meeting was held in the Cosmos Club April 22, 1925, President STEPHENSON presiding and 56 persons present. The Secretary announced the election to active membership of C E BATSCHELET, and V. A. POTTER.

Program: HAROLD T. STEARNS. *The great explosion of Kilauea Volcano in 1924.* (Illustrated with lantern slides.) Kilauea Volcano is located on the island of Hawaii, and rises 4,040 feet above sea level. On its summit is Kilauea caldera and Halemaumau, the "Pit of Everlasting Fire." The molten lava disappeared from view in Halemaumau on February 21, 1924, and left a pit 380 feet deep. Thirty-six local earthquakes occurred during February.

Seventy-eight earthquakes were recorded during March, many of which originated along the northeastern rift of Kilauea. No lava was visible during March. On April 29, there was a marked subsidence of the bottom of Halemaumau, and on the 30th, the bottom had sunk to 500 feet below the rim. Seismic activity increased during April, and on April 22-23, pronounced cracking and faulting began at Kapoho, 30 miles east of Kilauea. Fault

²⁹ From a report prepared by a committee consisting of Jeremy Belknap and Jedidiah Morse and printed in the Collections of the Massachusetts Historical Society, 1st series, 5: 29-30.

scarps 8-12 feet high, and fissures 15 feet wide developed. Three hundred and fifty-eight earthquakes were recorded at Kilauea Observatory during April. This faulting doubtless indicated a subsidence of the lava in the northeast rift.

At the end of the first week in May, the bottom of Halemaumau had subsided to 700 feet below the rim. During the night of May 10-11 the first explosion occurred. This small explosion was the beginning of the first explosive phase of Kilauea ever witnessed by white men. Explosions continued with increasing violence until they reached a maximum on Sunday morning, May 18. The maximum earthquake frequency, however, did not occur until May 24. The explosions of the morning of May 18 sent up a tight cauliflower cloud that reached a height of about 4 miles. A 10-ton block was hurled 3,500 feet from the crater of the pit, and ash fell 25 miles away. The dust cloud accompanying the great explosions of May 18 probably rose at the rate of 75 to 100 feet a second. Explosions continued at more or less regular intervals with decreasing intensity until May 27 when the pit returned to a condition of steaming, avalanching, and dust-making, similar to the period before May 11.

Three thousand nine hundred and sixty-one local earthquakes, and one teleseism were registered at the Observatory during the month of May. Lightning and thunder storms frequently accompanied the explosions.

No magmatic ejectamenta, no pumice, no cinders, nor Pele's hair were thrown out during the explosions. The projectiles consisted entirely of blocks of rock torn from the throat of Halemaumau. All evidence points to a phreatic origin for these steam explosions. The phenomenal collapse of the pit, the absence of magmatic ejecta, the low temperature, and other associated phenomena indicate that the lava column subsided below the ground water level under Kilauea. Ground water then entered the fissure-shaft and was heated by either hot rock or rising gas. The steam rose and collected under the talus plug in the bottom of Halemaumau until sufficient pressure had accumulated to blow out the plug. This process was repeated at more or less regular intervals until the plug no longer held or the supplying energy was dissipated. (*Author's abstract.*)

C. E. VAN OSTRAND. *A possible dependence of deep earth temperatures on geologic structure.* (Illustrated with lantern slides) The paper consisted chiefly of a brief review of some recent observations of temperatures in deep wells located in nine different oil pools in Wyoming. In five of the fields, Rawlins, Rock River, Big Muddy, Grass Creek, and Pine Mountain, the temperatures increase at the rate of about 1°F. in 50 to 60 feet, but in the remaining four pools, Warm Springs, Salt Creek, Lance Creek, and Lost Soldier, the rate ranges from 1°F. in 21.0 feet to 1°F. in 35.1 feet. A limited number of observations in the Lost Soldier and Warm Springs pools indicate a variation of temperature with reference to the structure the highest temperatures apparently being found on the top of the structure. The results of 22 observations in the Salt Creek field have been used by W. T. Thom, Jr., as a basis for the construction of a map showing the lines of equal rate of temperature increase. A composite map was used to show that the lines of equal rate of temperature increase are closely related to the contours on the usual contour map of the structure. As indicated in the other two pools, the highest temperatures at a given depth appear to be on the top of the structure. (*Author's abstract.*)

CHARLES BUTTS: *New light on the Talladega (Ocoee) rocks of Alabama*
EDWARD SAMPSON, J. D. SEARS, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

KIRK BRYAN and G. M. HALL, of the Water Resources Branch of the Geological Survey, have left Washington to assume their new duties on the teaching staffs respectively of Harvard University and the University of Tennessee.

A. E. FATH, formerly of the U. S. Geological Survey, recently visited Washington on his return from Europe, where he has been employed for three or four years in petroleum researches for the Vacuum Oil Company.

T. A. JAGGAR, in charge of the section of volcanology of the U. S. Geological Survey, has returned to the Hawaiian Volcano Observatory and will be assisted by R. M. WILSON and R. B. HODGES. R. H. FINCH has been assigned to take charge of the newly established Lassen Volcano Observatory at Lassen Peak, California.

OLIVE C. POSTLEY has been appointed Junior Geologist on the U. S. Geological Survey.

Dr. H. L. SHANTZ, of the Bureau of Plant Industry, U. S. Department of Agriculture has resigned and gone to the University of Illinois as professor of botany, succeeding Dr. WILLIAM TRELEASE, retired.

Dr. ARTHUR W. HILL, Director of Kew Gardens, England, spent some days in Washington, visiting the National Herbarium and studying methods of plant quarantine at the U. S. Department of Agriculture.

ELLSWORTH P. KILLIP and ALBERT C. SMITH, of the U. S. National Herbarium, left October 18 for Cartagena, Colombia, to carry on botanical exploration in the northern and eastern parts of that country. The work is a part of the project undertaken by the National Museum, the New York Botanical Garden, and the Gray Herbarium of Harvard University, for botanical investigations in northern South America. The Arnold Arboretum is also cooperating in the present expedition. Mr. KILLIP and Mr. SMITH expect to spend about six months in the field, exploring the coastal area about Cartagena and the little-known parts of the eastern Cordillera.

Dr. H. U. SVERDRUP sailed from New York, October 14, on the HELIG OLAF, for Norway, to take up the duties of Director of the Geophysical Institute B, at Bergen.

Mr. J. A. FLEMING returned to Washington on September 16, after a six-weeks' trip to California and Canada, during which he made arrangements for the installation of a horizontal intensity variometer at Mt. Wilson Observatory, and inaugurated a program of cooperative magnetic and astronomic observations during times of magnetic disturbances.

R. W. GORANSON, of Harvard University and S. B. HENDRICKS, of the California Institute of Technology, joined the staff of the Geophysical Laboratory, Carnegie Institution of Washington in September.

J. W. GREGG of the Geophysical Laboratory, who has been on a year's leave of absence, part of which was spent at Harvard University and part with the Canadian Geological Survey, resumed his work at the Laboratory in October.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 16

NOVEMBER 18, 1926

No. 19

POPULATION STATISTICS.—*The progressive adjustment of age distribution to fecundity.*¹ ALFRED J. LOTKA, Statistical Bureau, Metropolitan Life Insurance Company, New York.

It has been shown elsewhere² that, given a fixed age schedule of fecundity, that is to say, of maternity frequency among the females of a population, and given also a fixed age schedule of mortality (life table), the population will, in the absence of immigration and emigration, ultimately settle down to a certain definite age distribution, no matter what may have been the initial age distribution;³ and the form of this ultimate age distribution has also been given.

The successive stages through which the population passes from the original to the final age distribution have not, however, been previously determined numerically,⁴ neither has the lapse of time required for the adjustment been hitherto discussed. In what follows a numerical example will be treated so as to supply the missing information.

As a basis for the computation we shall take the white female population of the United States in 1920. The age distribution of this is exhibited, in quinquennial groups, in column (2) and (3) of Table 1.

The first step in the computation is to determine the age distribution of the survivors, in 1925, of this population of 1920. The population between the ages 20 and 25 in 1925, for example, was obtained by

¹ Received September 25, 1926.

² LOTKA, A. J. Phil. Mag. April, 1911, p. 435; Proc. Nat. Acad. Science 8: 339. 1922. *Elements of Physical Biology*, 1925, p. 110

³ Provided only that the initial age distribution was not so radically abnormal as to cause a complete cessation of reproduction.

⁴ Compare, however, E. CANNAN, *Economic Journal* 5: 21. 1895.

TABLE 1.—UNITED STATES WHITE FEMALE POPULATION, ON BASIS OF 1920 AGE DISTRIBUTION AND AGE SCHEDULE OF FERTILITY AND MORTALITY

AGE GROUP	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100	2105	2110	2115	2120	2125	2130	2135	2140	2145	2150	2155	2160	2165	2170	2175	2180	2185	2190	2195	2200	2205	2210	2215	2220	2225	2230	2235	2240	2245	2250	2255	2260	2265	2270	2275	2280	2285	2290	2295	2300	2305	2310	2315	2320	2325	2330	2335	2340	2345	2350	2355	2360	2365	2370	2375	2380	2385	2390	2395	2400	2405	2410	2415	2420	2425	2430	2435	2440	2445	2450	2455	2460	2465	2470	2475	2480	2485	2490	2495	2500	2505	2510	2515	2520	2525	2530	2535	2540	2545	2550	2555	2560	2565	2570	2575	2580	2585	2590	2595	2600	2605	2610	2615	2620	2625	2630	2635	2640	2645	2650	2655	2660	2665	2670	2675	2680	2685	2690	2695	2700	2705	2710	2715	2720	2725	2730	2735	2740	2745	2750	2755	2760	2765	2770	2775	2780	2785	2790	2795	2800	2805	2810	2815	2820	2825	2830	2835	2840	2845	2850	2855	2860	2865	2870	2875	2880	2885	2890	2895	2900	2905	2910	2915	2920	2925	2930	2935	2940	2945	2950	2955	2960	2965	2970	2975	2980	2985	2990	2995	3000	3005	3010	3015	3020	3025	3030	3035	3040	3045	3050	3055	3060	3065	3070	3075	3080	3085	3090	3095	3100	3105	3110	3115	3120	3125	3130	3135	3140	3145	3150	3155	3160	3165	3170	3175	3180	3185	3190	3195	3200	3205	3210	3215	3220	3225	3230	3235	3240	3245	3250	3255	3260	3265	3270	3275	3280	3285	3290	3295	3300	3305	3310	3315	3320	3325	3330	3335	3340	3345	3350	3355	3360	3365	3370	3375	3380	3385	3390	3395	3400	3405	3410	3415	3420	3425	3430	3435	3440	3445	3450	3455	3460	3465	3470	3475	3480	3485	3490	3495	3500	3505	3510	3515	3520	3525	3530	3535	3540	3545	3550	3555	3560	3565	3570	3575	3580	3585	3590	3595	3600	3605	3610	3615	3620	3625	3630	3635	3640	3645	3650	3655	3660	3665	3670	3675	3680	3685	3690	3695	3700	3705	3710	3715	3720	3725	3730	3735	3740	3745	3750	3755	3760	3765	3770	3775	3780	3785	3790	3795	3800	3805	3810	3815	3820	3825	3830	3835	3840	3845	3850	3855	3860	3865	3870	3875	3880	3885	3890	3895	3900	3905	3910	3915	3920	3925	3930	3935	3940	3945	3950	3955	3960	3965	3970	3975	3980	3985	3990	3995	4000	4005	4010	4015	4020	4025	4030	4035	4040	4045	4050	4055	4060	4065	4070	4075	4080	4085	4090	4095	4100	4105	4110	4115	4120	4125	4130	4135	4140	4145	4150	4155	4160	4165	4170	4175	4180	4185	4190	4195	4200	4205	4210	4215	4220	4225	4230	4235	4240	4245	4250	4255	4260	4265	4270	4275	4280	4285	4290	4295	4300	4305	4310	4315	4320	4325	4330	4335	4340	4345	4350	4355	4360	4365	4370	4375	4380	4385	4390	4395	4400	4405	4410	4415	4420	4425	4430	4435	4440	4445	4450	4455	4460	4465	4470	4475	4480	4485	4490	4495	4500	4505	4510	4515	4520	4525	4530	4535	4540	4545	4550	4555	4560	4565	4570	4575	4580	4585	4590	4595	4600	4605	4610	4615	4620	4625	4630	4635	4640	4645	4650	4655	4660	4665	4670	4675	4680	4685	4690	4695	4700	4705	4710	4715	4720	4725	4730	4735	4740	4745	4750	4755	4760	4765	4770	4775	4780	4785	4790	4795	4800	4805	4810	4815	4820	4825	4830	4835	4840	4845	4850	4855	4860	4865	4870	4875	4880	4885	4890	4895	4900	4905	4910	4915	4920	4925	4930	4935	4940	4945	4950	4955	4960	4965	4970	4975	4980	4985	4990	4995	5000	5005	5010	5015	5020	5025	5030	5035	5040	5045	5050	5055	5060	5065	5070	5075	5080	5085	5090	5095	5100	5105	5110	5115	5120	5125	5130	5135	5140	5145	5150	5155	5160	5165	5170	5175	5180	5185	5190	5195	5200	5205	5210	5215	5220	5225	5230	5235	5240	5245	5250	5255	5260	5265	5270	5275	5280	5285	5290	5295	5300	5305	5310	5315	5320	5325	5330	5335	5340	5345	5350	5355	5360	5365	5370	5375	5380	5385	5390	5395	5400	5405	5410	5415	5420	5425	5430	5435	5440	5445	5450	5455	5460	5465	5470	5475	5480	5485	5490	5495	5500	5505	5510	5515	5520	5525	5530	5535	5540	5545	5550	5555	5560	5565	5570	5575	5580	5585	5590	5595	5600	5605	5610	5615	5620	5625	5630	5635	5640	5645	5650	5655	5660	5665	5670	5675	5680	5685	5690	5695	5700	5705	5710	5715	5720	5725	5730	5735	5740	5745	5750	5755	5760	5765	5770	5775	5780	5785	5790	5795	5800	5805	5810	5815	5820	5825	5830	5835	5840	5845	5850	5855	5860	5865	5870	5875	5880	5885	5890	5895	5900	5905	5910	5915	5920	5925	5930	5935	5940	5945	5950	5955	5960	5965	5970	5975	5980	5985	5990	5995	6000	6005	6010	6015	6020	6025	6030	6035	6040	6045	6050	6055	6060	6065	6070	6075	6080	6085	6090	6095	6100	6105	6110	6115	6120	6125	6130	6135	6140	6145	6150	6155	6160	6165	6170	6175	6180	6185	6190	6195	6200	6205	6210	6215	6220	6225	6230	6235	6240	6245	6250	6255	6260	6265	6270	6275	6280	6285	6290	6295	6300	6305	6310	6315	6320	6325	6330	6335	6340	6345	6350	6355	6360	6365	6370	6375	6380	6385	6390	6395	6400	6405	6410	6415	6420	6425	6430	6435	6440	6445	6450	6455	6460	6465	6470	6475	6480	6485	6490	6495	6500	6505	6510	6515	6520	6525	6530	6535	6540	6545	6550	6555	6560	6565	6570	6575	6580	6585	6590	6595	6600	6605	6610	6615	6620	6625	6630	6635	6640	6645	6650	6655	6660	6665	6670	6675	6680	6685	6690	6695	6700	6705	6710	6715	6720	6725	6730	6735	6740	6745	6750	6755	6760	6765	6770	6775	6780	6785	6790	6795	6800	6805	6810	6815	6820	6825	6830	6835	6840	6845	6850	6855	6860	6865	6870	6875	6880	6885	6890	6895	6900	6905	6910	6915	6920	6925	6930	6935	6940	6945	6950	6955	6960	6965	6970	6975	6980	6985	6990	6995	7000	7005	7010	7015	7020	7025	7030	7035	7040	7045	7050	7055	7060	7065	7070	7075	7080	7085	7090	7095	7100	7105	7110	7115	7120	7125	7130	7135	7140	7145	7150	7155	7160	7165	7170	7175	7180	7185	7190	7195	7200	7205	7210	7215	7220	7225	7230	7235	7240	7245	7250	7255	7260	7265	7270	7275	7280	7285	7290	7295	7300	7305	7310	7315	7320	7325	7330	7335	7340	7345	7350	7355	7360	7365	7370	7375	7380	7385	7390	7395	7400	7405	7410	7415	7420	7425	7430	7435	7440	7445	7450	7455	7460	7465	7470	7475	7480	7485	7490	7495	7500	7505	7510	7515	7520	7525	7530	7535	7540	7545	7550	7555	7560	7565	7570	7575	7580	7585	7590	7595	7600	7605	7610	7615	7620	7625	7630	7635	7640	7645	7650	7655	7660	7665	7670	7675	7680	7685	7690	7695	7700	7705	7710	7715	7720	7725	7730	7735	7740	7745	7750	7755	7760	7765	7770	7775	7780	7785	7790	7795	7800	7805	7810	7815	7820	7825	7830	7835	7840	7845	7850	7855	7860	7865	7870	7875	7880	7885	7890	7895	7900	7905	7910	7915	7920	7925	7930	7935	7940	7945	7950	7955	7960	7965	7970	7975	7980	7985	7990	7995	8000	8005	8010	8015	8020	8025	8030	8035	8040	8045	8050	8055	8060	8065	8070	8075	8080	8085	8090	8095	8100	8105	8110	8115	8120	8125	8130	8135	8140	8145	8150	8155	8160	8165	8170	8175	8180	8185	8190	8195	8200	8205	8210	8215	8220	8225	8230	8235	8240	8245	8250	8255	8260	8265	8270	8275	8280	8285	8290	8295	8300	8305	8310	8315	8320	8325	8330	8335	8340	8345	8350	8355	8360	8365	8370	8375	8380	8385	8390	8395	8400	8405	8410	8415	8420	8425	8430	8435	8440	8445	8450	8455	8460	8465	8470	8475	8480	8485	8490	8495	8500	8505	8510	8515	8520	8525	8530	8535	8540	8545	8550	8555	8560	8565	8570	8575	8580	8585	8590	8595	8600	8605	8610	8615	8620	8625	8630	8635	8640	8645	8650	8655	8660	8665	8670	8675	8680	8685	8690	8695	8700	8705	8710	8715	8720	8725	8730	87
-----------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	----

multiplying the population between the ages 15 and 20 in 1920^a by the factor $l_{25.5} / l_{17.5}$. Similarly all the other age groups from age five to the end of life, in 1925, were computed. The age group 0-5 cannot, of course, be found by this method, but must be derived from the births in the quinquennium 1920-1925. These were estimated as follows:

For 1920 the birth rate of white females was known from official sources.

For 1925 the birth rate of daughters was computed by multiplying the female population in each age group from 10 to 54 in 1925 by the corresponding^b maternity frequency, as shown in Table 2. The sum

TABLE 2.—SURVIVORS, IN 1925, OF UNITED STATES WHITE FEMALE POPULATION 1920, ALSO, MATERNITY FREQUENCY 1920, AND RESULTING BIRTHS PER ANNUM

(1) AGE	(2) NUMBER	(3) MATERNITY FREQUENCY DAUGHTERS PER 100,000 FEMALES PER ANNUM*	(4) = (2) × (3)
10-14	4,943,467	9	445
15-19	4,579,575	2202	100,842
20-24	4,084,269	7310	298,560
25-29	4,046,509	7480	302,679
30-34	3,915,636	5780	226,324
35-39	3,443,062	3898	134,211
40-44	3,186,211	1552	49,450
45-49	2,657,507	172	4,571
50-54	2,284,954	5	114
10-54	33,141,210		1,117,196

* According to Birth Statistics for the Birth Registration Area of the United States, Sixth Annual Report, Census Bureau, 1920 p. 169, United States Census Report, 1920, 2: 162, after distributing the "unknown"

of the products so obtained, taken over all the reproductive age groups, gives the total births of daughters.

^a The values of l_x used here and throughout the work were those given by E. Foudray in the "United States Abridged Life Tables 1919-20" for white females, "Aggregate" of all available States. These tables give l_x and q_x for ages 2, 7, 12, etc. From these $l_{x.5}$, $l_{x.1}$, etc. are easily obtained by the usual actuarial methods.

^b That is, the numbers of daughters born per annum per head of white female population in each age group. The numerical data required are to be found in the "Birth Statistics for the Registration Area of the United States 1920," pp. 44 et seq. (Population by States) and pp. 168 et seq. (Births by Sex and by Age of Mother). The totals for 23 states were obtained by actual addition, instead of using the totals given in the "Summary" on p. 44, as this latter includes the State of Maine, for which only the gross number of births is available without classification by age of mother.

For intervening years, 1921-1924, total births were estimated by simple linear interpolation.

Having thus obtained values of the total births of daughters for the years 1920-1925, the survivors in the age group 0-5 in 1925 were computed as follows: Denoting by B_{1920} , B_{1921} , etc., the total births in the year 1920, 1921, etc., the survivors in question were determined as the sum

$$B_{1920} \quad l_{4.5} + B_{1921} \quad l_{3.5} + B_{1922} \quad l_{2.5} + B_{1923} \quad l_{1.5} + B_{1924} \quad l_{0.5}$$

The complete age distribution of the white female population in 1925 having thus been determined, a simple repetition of the process gives the age distribution for 1930, a second repetition gives the distribution for 1935, and so on.

TABLE 3.—BIRTHRATE, DEATHRATE, AND RATE OF NATURAL INCREASE, UNITED STATES WHITE FEMALES 1920-1985, COMPUTED ON BASIS OF FECUNDITY AND MORTALITY AGE SCHEDULES AS OF 1920

	1920	1925	1930	1935	1940	1945
Birthrate b (daughters, per annum, per head of female population)	2 340	2 276	2 247	2 232	2 200	2 156
Death rate d (deaths of females, per annum, per head of female population)	1 241	1 191	1 228	1 277	1 319	1 358
Rate of increase $r = b - d$. . .	1 099	1 085	1 019	0 955	0.881	0 798

	1950	1955	1960	1965	1970	1975	1980	1985	∞^*
b . . .	2 120	2 100	2 094	2 097	2.098	2 094	2 089	2 087	2.091
d . . .	1 400	1 442	1 479	1.508	1 526	1 534	1.537		1 544
r	0 720	0 658	0.615	0 589	0.572	0 560	0 552		0.547

* Computed by formulae (1), (2).

The computation was carried as far as the year 1985. The resulting figures, and also the ultimate age distribution after complete adjustment ("after an infinite lapse of time") are shown in successive columns of Table 1. For the sake of economy in typesetting, percentages only, not actual numbers, are shown for certain years, though the actual numbers were calculated in carrying out the computation. It will be seen that by 1985 the "ultimate" or fixed age distribution is very nearly attained. Table 3 and Figure 1 show the birthrates per head

and natural rate of increase per head obtained by simple division from the total births and the total population computed as indicated above for the several years of the period covered. The corresponding

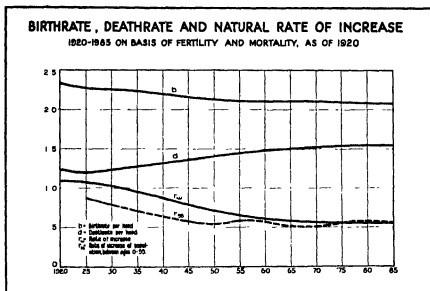


FIG. 1.—Birth rate, death rate, and natural rate of increase, U. S. 1920-1985, computed on basis of fecundity and mortality as of 1920.

death rates follow immediately as the excess of the birth rate over the natural rate of increase. These death rates also are shown in Table 3 and Figure 1. The results thus obtained relate strictly only to the "birthrate of daughters per annum per head of female population." But this figure differs in any case but little from the birthrate as ordinarily computed on the basis of children of both sexes and population of both sexes, and for our present purposes it is not worth while applying a correction.

It serves as a check upon the computation here presented that the final result is in very good agreement with the values of the ultimate birthrate and ultimate natural rate of increase computed by the fundamental formulae:

$$1 = \int_0^{\infty} e^{-ra} p(a) m(a) da \quad (1)$$

$$1/b = \int_0^{\infty} e^{-ra} p(a) da \quad (2)$$

given in the references cited above. The values obtained by these

formulae are shown, for comparison, in the last column of Table 3, along with those computed for 1985 and 1980 as described above.

It should be understood that the figures here presented are not intended as in any sense a forecast of the birthrates actually to be expected in coming years. Aside from immigration (henceforth to be greatly restricted), two factors will operate to modify the actual as compared with the computed birthrates, namely, (1) the change

UNITED STATES POPULATION, 1920-2000

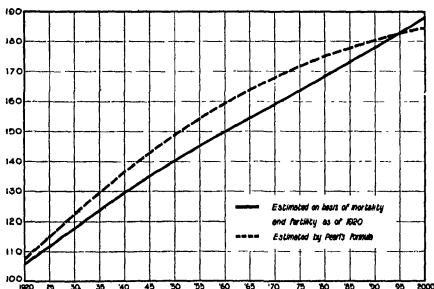


FIG. 2—U S population 1920-2000 computed (a) according to Pearl and Reed's formula; (b) on the basis of fecundity and mortality as of 1920

(probably decrease) in maternity frequencies; and (2), the change (increase) in survival at all ages, which finds general expression in the increase in the mean length of life. The interest in the figures presented lies in the insight they give into the ultimate age distribution and the resulting birthrates and death rates which would follow from a continuation of *present* conditions of fecundity and survival (mortality); and further, in the information furnished regarding the lapse of time that would be required to bring about adjustment and the successive steps by which this is actually brought about.

It is also interesting to compare the figures thus obtained⁷ for the

⁷ The total population has in this estimate, been obtained by multiplying the white female population by the factor 2.28 which represents the ratio of total to white female population in 1920

total population with the forecast given by the formula of Pearl and Reed. This comparison is shown in Figure 2. As would be expected, for many years to come the computed figures fall short of the Pearl and Reed population, which latter corresponds to a law of growth including the influence of immigration. Whether, upon restriction of immigration, the birthrate of the native population will increase to meet the new "demand" is a question which most persons will be disposed to answer in the negative. It should be repeated that the figures here given are not to be construed as a forecast of what actually will occur, but as an indication of the course of events which would ensue if present conditions of mortality and fecundity continued unchanged. Under these conditions the population curve would cross



FIG. 3.—Model of age distribution in U. S. population (white females) 1920-1935. computed on basis of fecundity and mortality as of 1920.

the Pearl curve about the year 1995 and the population would thereafter exceed that calculated according to Pearl.

In actual fact, no doubt, fecundity will continue to decline in the future as it has in the past, and the curve of population growth will eventually become less steep than computed for existing conditions.

Another feature brought out by the computation here presented is that the ultimate rate of increase of the population is determined wholly by that part of the female population which is comprised within

reproducing ages, say ten years to fifty-five years. It is, in fact, unnecessary, except as a matter of curiosity, to carry any of the computations described above beyond age fifty-five, if we are interested merely in determining the ultimate rate of increase. If we had omitted all figures above age fifty-five we should have obtained only the results above the double-ruled line in Table 1. On the basis of these alone we should find a series of values for r similar in a general way to that obtained from a consideration of the population as a whole. This is clearly seen in Figure 1, which exhibits graphically the curve of r_{∞} computed for the entire population, and r_{ss} , that computed on the

TABLE 4 —THE "AGEING" OF THE AMERICAN POPULATION

(1)	(2)	(3)
Year	Proportion of Population of Age	
	15-54 years	55 and over
1870*	53.4	3.0
1880	53.7	3.4
1890	55.4	3.7
1900	56.0	4.0
1910	58.0	4.1
1920†	57.1	4.9
1930‡	57.7	5.7
1940	56.7	6.8
1950	55.4	8.0
1960	55.1	8.9
1970	54.6	9.0
1980	54.6	9.4
Ultimate	54.5	9.4
Stationary	55.5	10.5

* 1870 to 1920 persons of both sexes, white and colored.

† 1920 to end, white females of 23 States.

‡ 1930 to end, computed on basis of 1920 age schedule of fecundity.

basis of the population under fifty-five years of age alone.* It will be seen that, while individual values of r_{ss} and r_{∞} differ, and while r_{∞} gives a much smoother curve than r_{ss} , yet both curves approach the same asymptote.

The gradual approach, from the initial age distribution in 1920, to that of 1985 (almost identical with the ultimate age distribution) is best seen in a three-dimensional model such as that shown in photographic reproduction in Figure 3. Consecutive quinquennia are

* It is, of course, impossible to calculate correctly the ultimate value of r on the basis of a portion of the population, such as age 0-50, which omits an essential part of the reproducing population.

shown alternately in white and black, as an aid to the eye in identifying the quinquennial slices, representing the population by age in 1920 (white), 1925 (black), 1930 (white), etc. The last white slice is labeled "Infinity," and corresponds to the "ultimate" age distribution determined by the 1920 mortality (life table) and age schedule of maternity frequency.

The model clearly exhibits the following features:

1. The increase in the proportion of older persons from 1920 to later dates. Note the upward stepping of the blocks from left to right near the front of Figure 3.
2. The decrease in the proportion of younger persons. Note the "sky line" at the top. This also indicates the decreasing birthrate. This gradual ageing of the population is also clearly brought out in Table 4.
3. The gradual smoothing out of the roughnesses of the original age distribution (on left), until finally the "smooth" ultimate distribution is reached.
4. In the 65 years from 1920 to 1985 the "ultimate" age distribution is practically attained.

The gradual "ageing" of the population referred to under 1 and 2 above appears essentially as a continuation of a process which has actually been going on for many years past, as shown in column 3 of Table 4.

Column 2 of this table, on the other hand, shows that we may expect only comparatively little change in the proportion of the population comprised between the ages of 15 and 55, the essentially productive and reproductive period of life. There will tend to be fewer children, more "old" people (65 and over), but about the same number of persons in the middle ranges of life.

GEOLOGY.—*The restoration of Ostrea multilirata Conrad, 1857.*¹

JULIA A. GARDNER. U. S. Geological Survey.

The possibility of the identity of *Ostrea tasei* Gardner with the earlier *Ostrea multilirata*² Conrad was suggested in the original description of *O. tasei*. At that time I discussed their relationship as follows:³

Ostrea tasei is probably identical with *Ostrea multilirata* Conrad, collected from the so-called Cretaceous of "Dry Creek, Mexico." Conrad's types are in the National Museum and are fairly well preserved. Nothing of the kind has been reported from the Cretaceous by later investigators who have collected extensively in the Rio Grande area. However, *Ostrea cortex*, col-

¹ Received October 1, 1926.

² CONRAD, T. A., U. S. and Mex. Boundary Survey Rept. 1: (pt. 2) 157, pl. 12, figs. 1a-d. 1857.

³ GARDNER, JULIA, U. S. Geol. Survey Professional Paper 131: (D) 109. 1923.

lected at the same locality, is certainly a Cretaceous species, and until "Dry Creek" can be definitely located and the confusion in the stratigraphic relations cleared the Wilcox form may well be kept apart.

When I was working out from Eagle Pass in the summer of 1925, I attempted to locate "Dry Creek," obviously a translation if the *Ostrea* in question really came from the Mexican side, and a descriptive term applied to a large percentage of the arroyos of southwest Texas and the adjoining section of Mexico. Not even the oldest ranchman with his thorough familiarity with local names in years long past could give me any helpful information and I am convinced that Conrad's *Dry Creek* has no standing as a geographic term. As many of his boundary localities are rather confused, it is quite possible that his species did not come from the Mexican side at all but from the Texas. The drainage upon the Texas side contributes readily to the co-mingling of the Wilcox and Cretaceous species. In southern Maverick County, about 28 miles southwest of Eagle Pass, I found collecting conditions which may very well have been similar to those which caused Conrad's confusion. Tobar arroyo twists from Tobar tank about 2 miles north of the Windmill Ranch House to the Rio Grande, a distance of about ten miles by stream bed. It is dry during the greater part of the year but becomes a powerful torrent in the sudden heavy rains of that section of the country. The valley is consequently quite deep and the stream bed covered with coarse debris. The upper part of the course cuts the Wilcox and the heavy oyster reef near the base, tearing down the oysters and scattering them about the valley in the greatest profusion. The shells are very resistant and are often protected to a certain extent by the matrix. They continue to be abundant in the stream debris throughout the length of the Midway outcrop and near the Rio Grande, where the arroyo cuts the Cretaceous, they are commonly mingled with *Ostrea cortex*. There is no reasonable doubt, in my opinion, that Conrad collected his *Ostrea cortex* and *Ostrea multilirata* under conditions analogous to those of Tobar arroyo and, though it is most unfortunate that the type locality of Conrad's species can not be definitely located, I do not think that the resulting obscurity is sufficiently great to invalidate his species. I therefore propose that the name *Ostrea tasei* Gardner be suppressed in favor of *Ostrea multilirata* Conrad, 1857.

ORNITHOLOGY.—*Descriptions of nineteen new East Indian passerine birds.*¹ HARRY C. OBERHOLSER, U. S. National Museum.

The following pages contain descriptions of 19 new birds, in the United States National Museum collection, belonging to the passerine families *Hirundinidae*, *Graculidae* (= *Eulabetidae*), *Campephagidae*, *Dicruridae*, *Dicaeidae*, and *Ploceidae*.

Measurements are given in millimeters, and have been taken as in the author's previous papers. Names of colors are based on Ridgway's "Color Standards and Color Nomenclature."

HIRUNDINIDAE

Hypurolepis javanica hypolampra, subsp. nov.

Subspecific characters.—Similar to *Hypurolepis javanica javanica*, of Java, but larger; and with the posterior lower parts lighter, their median portion whitish.

Description.—Type, adult female, No. 179936, U. S. Nat. Mus.; Lafau, Nias Island, Barussan Islands, western Sumatra, March 22, 1903; Dr. W. L. Abbott. Forehead between auburn and chestnut, rest of upper parts metallic bluish slate black, tail chaetura black with a faint greenish sheen, and with subterminal spots of white; wings chaetura black with a faint greenish sheen, passing on the inner margins of the quills to fuscous, the lesser coverts edged with the color of the back; lores black; sides of head and of neck like the back; chin and throat cinnamon rufous, verging a little toward tawny; posterior lower parts dull white, streaked on the sides, flanks, and crissum with brownish drab; lining of wing rather dark hair brown, the feathers with drab edgings.

Measurements of type.—Wing, 103 mm.; tail, 45; exposed culmen, 8.5; tarsus, 10.5; middle toe without claw, 11.

Swallows of this species from Sumatra belong apparently to this race, as probably also do those from the southern Malay Peninsula. This new subspecies seems to be, in its lighter, brighter posterior under surface, sufficiently different from *Hypurolepis javanica domicola* (Jerdon) of southern India.

Hypurolepis javanica mallopega, subsp. nov.

Subspecific characters.—Resembling *Hypurolepis javanica frontalis* (Celebes examples) but averaging somewhat larger; forehead, throat, and middle of posterior lower parts averaging paler; sides and flanks lighter, and averaging also more brownish (less grayish) and more uniform (less spotted) in appearance.

Type.—Adult male, No. 202219, U. S. Nat. Mus.; Mt. Santo Tomas, altitude 5,250 ft., Benguet, Island of Luzon, Philippine Islands, December 31, 1906; Dr. E. A. Mearns; original number, 14642.

Measurements of type.—Wing, 107 mm.; tail, 50; exposed culmen, 8.5; tarsus, 10; middle toe without claw, 10.

The birds of this species from apparently all the Philippine Islands belong to this race.

¹ Received September 20, 1926.

GRACULIDAE

Lamprocorax panayensis eustathis, subsp. nov.

Subspecific characters.—Similar to *Lamprocorax panayensis insidiator*, from Sumatra, but with green of plumage more oily or yellowish.

Description.—Type, adult male, No. 182998, U. S. Nat. Mus.; Kota Bangoen, eastern Borneo, January 30, 1914; H. C. Raven. Entire plumage, excepting the remiges and the rectrices, metallic bottle green with a slight bronzy tinge, the chin and throat with a very slight purplish sheen; remiges and rectrices blackish on their upper surfaces, with steel greenish, bluish, and purplish reflections; lower surface of tail and wings blackish clove brown, the under wing-coverts and axillars margined with metallic green.

Measurements of type.—Wing, 93.5 mm.; tail, 63; exposed culmen, 15.5; height of bill at base, 7.5; tarsus, 20.5; middle toe without claw, 17.

This new race is so much smaller than *Lamprocorax panayensis heterochlorus* of the Anamba Islands that there is no danger of confusing it with that form.

Lamprocorax panayensis alipodis, subsp. nov.

Subspecific characters.—Resembling *Lamprocorax panayensis eustathis*, from the mainland of eastern Borneo, but much larger, and of a much more bluish (less oily or yellowish) green.

Type.—Adult male, No. 182435, U. S. Nat. Mus.; Pulo Pandigang, eastern Borneo, May 2, 1913; H. C. Raven.

Measurements of type.—Wing, 111 mm.; tail, 81; exposed culmen, 19; height of bill at base, 8; tarsus, 23.5; middle toe without claw, 19.

Lamprocorax panayensis nesodramus, subsp. nov.

Subspecific characters.—Resembling *Lamprocorax panayensis rhadinorhamphus*, from Simalur Island, western Sumatra, but feet decidedly larger, other measurements somewhat larger, except bill, which is relatively smaller.

Type.—Adult male, No. 179273, U. S. Nat. Mus.; Pulo Babi, Barussan Islands, western Sumatra, January 13, 1902, Dr. W. L. Abbott.

Measurements of type.—Wing, 103 mm.; tail, 65.5; exposed culmen, 15.5; height of bill at base, 8; tarsus, 23; middle toe without claw, 18.5.

Lamprocorax panayensis haliotypus, subsp. nov.

Subspecific characters.—Similar to *Lamprocorax panayensis affinis*, from northeastern India, but smaller, and of a more oily green, without much bronzy purplish sheen.

Type.—Adult male, No. 153845, U. S. Nat. Mus.; Telibon Island, Trang, Lower Siam, March 1, 1896; Dr. W. L. Abbott.

Measurements of type.—Wing, 100 mm.; tail, 66; exposed culmen, 15.5; height of bill at base, 6.5; tarsus, 22; middle toe without claw, 17.5.

The Malay Peninsula bird, here described, differs from *Lamprocorax panayensis insidiator* of Sumatra in larger size, and in the more bronzy tinge of the plumage.

Gracula javana halibretha, subsp. nov.

Subspecific characters.—Similar to *Gracula javana andamanensis*, from the Andaman Islands, but larger.

Description.—Type, adult male, No. 178596, U. S. Nat. Mus.; Little Nicobar Island, Nicobar Islands, February 27, 1901; Dr. W. L. Abbott. Entire plumage black, excepting a large white spot on the middle of the six outer primaries; middle of crown, the back, and jugulum with a metallic violet or bronzy violet sheen; throat and chin with a dull greenish blue sheen; sides of crown, sides of occiput, all of the lower back, rump, upper tail-coverts, breast, abdomen, thighs, and crissum, with a metallic sheen of dark American green; margins of all the superior wing-coverts, except the greater series, with glossy bluish, greenish, or violet sheen, wing-quills and rectrices with slightly bluish or greenish reflections, excepting the inner webs of the former, which are brownish, and decidedly paler along the basal portion of the inner margins.

Measurements of type.—Wing, 184.5 mm.; tail, 93; exposed culmen, 17.5; height of bill at base, 15; greatest width of lappets, 15; tarsus, 10; middle toe without claw, 27.

CAMPEPHAGIDAE

Artamides sumatrensis messeris, subsp. nov.

Subspecific characters.—Similar to *Artamides sumatrensis sumatrensis*, from Sumatra, but upper and lower parts paler, particularly in the male; size larger.

Description.—Type, adult male, No. 169789, U. S. Nat. Mus.; Trang, Lower Siam, March 3, 1899; Dr. W. L. Abbott. Upper parts between dark gull gray and neutral gray, the forehead, rump and upper tail-coverts paler, tail brownish black, primaries also brownish black, secondaries and tertials, dark neutral gray, the wing-coverts and the basal portions of the outer edges of the wing-quills gray like the back, the outer edges of the secondaries terminally, the outer edges of the primaries medially, and the outer webs of the tertials, gray, similar to the back but lighter. sides of head and of neck like the back; lower parts light neutral gray, slightly darker on the chin and throat, and paling on the abdomen to pallid neutral gray, crissum buffy grayish white, rather broadly barred with neutral gray, under wing-coverts white, barred with blackish outwardly, and with light neutral gray elsewhere.

Measurements of type.—Wing, 158 mm., tail, 108; exposed culmen, 24.5; height of bill at base, 13; tarsus, 23.5; middle toe without claw, 19.5.

Artamides sumatrensis nesiarchus, subsp. nov.

Subspecific characters.—Similar to *Artamides sumatrensis sumatrensis*, from Sumatra, but larger; in the female with less white (more gray) on rump, and with slightly heavier black bars on posterior lower parts, particularly the crissum.

Type.—Adult male, No. 180225, U. S. Nat. Mus.; Pulo Parit, near Karim Island, eastern Sumatra; June 11, 1903; Dr. W. L. Abbott.

Measurements of type.—Wing, 160 mm., tail, 107.5; exposed culmen, 28; height of bill at base, 12.5; tarsus, 24.5; middle toe without claw, 19.

Although this subspecies is geographically intermediate between *Artamides sumatrensis sumatrensis* of Sumatra and *Artamides sumatrensis messeris* of the Malay Peninsula, it is larger than either, and further differs from the latter, in the male, by reason of darker coloration above and below, and more ashy (less whitish), usually less numerous and less distinctly barred, under tail-coverts; in the female by reason of somewhat darker coloration, less white

on the rump and upper tail-coverts, and somewhat narrower white bars on the abdomen and lower breast.

DICRURIDAE

Dissemurus paradiseus mallomicrus, subsp. nov.

Subspecific characters.—Similar to *Dissemurus paradiseus rangoonensis* from Burma, but smaller, crest shorter, and racquet broader and longer.

Description.—Type, adult male, No. 178660, U. S. Nat. Mus.; Hastings Island, Mergui Archipelago, December 11, 1900; Dr. W. L. Abbott. Entire plumage brownish black, all the exposed parts of the body plumage, except on the chin, throat, abdomen, and flanks, glossy metallic greenish or bluish, this on the breast taking the form of apical spots; wings and tail somewhat shiny brownish black, the rectrices and remiges with their outer webs mostly metallic greenish or bluish; the exposed surface of the upper wing-coverts similar.

Measurements of type.—Wing, 152.5 mm; tail, 342; tail except racquet feathers, 145; length of racquet, 100; greatest width of racquet, 20; total culmen, 32.5; height of bill at base, 13.5; longest feather of frontal crest, 22; tarsus, 24.5.

This subspecies is apparently confined to the Mergui Archipelago.

Dissemurus paradiseus hypoballus, subsp. nov.

Subspecific characters.—Similar to *Dissemurus paradiseus mallomicrus*, from the Mergui Archipelago, but readily distinguishable by smaller size, shorter frontal crest, and smaller racquet.

Type.—Adult male, No. 153820, U. S. Nat. Mus.; Prahmon, Trang, Lower (Peninsular) Siam, April 1, 1896; Dr. W. L. Abbott.

Measurements of type.—Wing, 149.5 mm; tail, 350.5; tail except racquet feathers, 143; total culmen, 28.5; height of bill at base, 11; tarsus, 24.5; length of racquet, 78; greatest width of racquet, 21.5; longest feather of frontal crest, 16.5.

This race differs from *Dissemurus paradiseus paradiseus*, of Siam, in shorter wing, much shorter frontal crest, and much smaller racquet. It occupies the Malay Peninsula south of Tenasserim, but not the island of Singapore.

For this bird Mr. E. C. Stuart Baker has used¹ the name *Dissemurus paradiseus setifer* (Cabanis);² but an examination of the basis of this name shows it to be unavailable for use in this connection. It is introduced, without any description, and without citation other than as follows:

"599 l. D. setifer Nob—

Edolus setifer (err. retifer) Temm.—Java; Sumatra. Mas. ad. et Jun.; Febr. 3 St."

It is thus evidently not intended as a new name but as merely the adoption of Temminck's *Edolus setifer* as the name for the birds that Cabanis had in hand. In fact, the only thing that could save it from being an absolute nomen nudum is the citation "*Edolus setifer* (err. retifer) Temm."; and it must be

¹ *Novitates Zoologicae* 25: (No. 1) 300. May 1, 1918.

² [*Dissemurus*] *setifer* Cabanis, Mus. Hein 1: 111. 1851 (after October 23).

thus of identical application. Temminck proposed the name *Edolius retifer* as follows:⁴ "Le *Drongo à raquettes* que nous proposons de nommer *Edolius retifer* en remplacement de *Lanius malabaricus*." Later in the same work⁵ he emended it to *Edolius setifer*. Thus both *Edolius retifer* Temminck and *Edolius setifer* Temminck are pure synonyms of *Lanius malabaricus* Latham, which is *Dissemurus paradiseus malabaricus* (Latham). Consequently *Dissemurus setifer* Cabanis, which as above shown, is based wholly on these names of Temminck's, must likewise be a synonym of the same, and as such is, of course, not usable for the Malay Peninsula subspecies.

Neither is [*Edolius*] *Malayensis*, applied by Jerdon⁶ to this drongo, a tenable name for the Malay race, since this is, though cited as its name, merely a mistaken identification of *Chaptia malayensis* Blyth,⁷ which is not a *Dissemurus* at all, but *Chaptia aenea malayensis*.

Under these circumstances, the present form seems properly above provided with a new subspecific title.

***Dissemurus paradiseus messatus*, subsp. nov.**

Subspecific characters.—Similar to *Dissemurus paradiseus hypoballus*, but racquet narrower and crest shorter.

Type.—Adult male, No. 170451, U. S. Nat. Mus.; Selitar, 9 miles from the town of Singapore, Singapore Island, Federated Malay States, May 29, 1899, Dr. W. L. Abbott.

Measurements of type.—Wing, 148.5 mm; tail, 312; tail except racquet feathers, 148; length of racquet, 82; greatest width of racquet, 18; total culmen, 32; height of bill at base, 11.5; longest feather of frontal crest, 9; tarsus, 24.

It is apparently confined to the island of Singapore.

***Dissemurus paradiseus siakensis*, subsp. nov.**

Subspecific characters.—Resembling *Dissemurus paradiseus messatus*, of Singapore, but racquet averaging smaller, frontal crest shorter (practically absent), stiffer, and denser.

Type.—Adult male, No. 181264, U. S. Nat. Mus.; Siak River, eastern Sumatra, December 22, 1906, Dr. W. L. Abbott.

Measurements of type.—Wing, 142.5 mm.; tail, 357.5; tail except racquet feathers, 145; length of racquet, 69; greatest width of racquet, 17; total culmen, 32.5; height of bill at base, 12; longest feather of frontal crest, 6; tarsus, 21.

The distribution of this race includes the eastern coast region of Sumatra and at least the near-by islands.

⁴ Nouv. Rec Planches Col d'Oiseaux 3 (livr. 30): texte to pl 178, p. [1] January, 1823.

⁵ Nouv. Rec Planches Col d'Oiseaux 1 (livr 102): Tableau Methodique. 20. January 29, 1839.

⁶ Birds of India, 1: 438. 1862.

⁷ *Ch[aptia]. malayensis* Blyth (A. HAY MS), Journ Asiatic Soc. Bengal, 15: 294. 1846 (after April). ("Malacca")

***Dissemurmus paradiseus colpiotes*, subsp. nov.**

Subspecific characters.—Similar to *Dissemurmus paradiseus siakensis* of eastern Sumatra, but with frontal crest thinner, the feathers, particularly on the anterior portion, broader, less bristly, and usually longer, racquet shorter; and bill somewhat heavier.

Type.—Adult male, No. 179245, U. S. Nat. Mus.: Loh Sidoh Bay, north-western Sumatra, November 6, 1901; Dr. W. L. Abbott

Measurements of type.—Wing, 148 mm.; tail, 306;* tail except racquet feathers, 136, length of racquet, 63.5; greatest width of racquet, 17.5; total culmen, 31; height of bill at base, 13.5; longest feather of frontal crest, 9.5; tarsus, 23.5.

This race of western Sumatra seems to be distinguishable from all the subspecies of the islands of the Barussan chain, as well as from the form of the species inhabiting eastern Sumatra.

DICAËIDAE***Dicaeum trigonostigmum pagense*, subsp. nov.**

Subspecific characters.—Similar to *Dicaeum trigonostigmum croceiventre* (Borneo specimens), but upper parts including back and rump lighter, rump more yellowish (less orange); throat paler

Description.—Type, adult male, No. 180065, U. S. Nat. Mus.; South Pagi Island, Barussan Islands, western Sumatra, November 16, 1902; Dr. W. L. Abbott. Pileum and cervix green-blue slate, the cervix a little darker, scapulars and upper tail-coverts of the same color, but a little mixed or tinged with olive, back mikado orange; rump bright analine yellow, tail black, slightly brownish and with a slightly metallic bluish sheen; wings between dark mouse gray and blackish mouse gray, margined with the color of the scapulars, except the secondary coverts which are rather deep delft blue, sides of head like the crown, but the cheeks duller, sides of neck like the cervix, chin and throat, light neutral gray, breast and sides, orange; flanks and abdomen, cadmium yellow, but the middle of lower abdomen and under tail-coverts wax yellow; lining of wing white.

Measurements of type.—Wing, 48.5 mm.; tail, 23, exposed culmen, 9.5; tarsus, 13, middle toe without claw, 8.

This race is distinguishable from *Dicaeum trigonostigmum cyprum*, of Nias Island, by its paler upper surface, and more yellowish (less orange) rump and trisum.

PLOCEIDAE***Uroloncha acuticauda lepidota*, subsp. nov.**

Subspecific characters.—Similar to *Uroloncha acuticauda acuticauda*, from India, but upper parts less rufescent (more grayish); auriculars more conspicuously spotted with white; feathers of sides of throat and of breast, with breast and jugulum, broadly margined with whitish or buffy, giving to these parts a much squamate appearance; posterior lower parts more noticeably streaked.

Description.—Type, adult male, No. 154014, U. S. Nat. Mus.; Tyehing, Trang, Lower Siam, May 23, 1896; Dr. W. L. Abbott. Crown dark

* Racquet feathers not fully grown.

fuscous; rump brownish white; upper tail-coverts clove brown, edged with buffy brown and streaked with white; remainder of upper parts olive brown streaked with white; tail brownish black, wings fuscous, exteriorly edged with fuscous back, the inner edges of the secondaries pinkish buff; nasal plumes, lores, periorbital region, and cheeks, brownish black, auriculars between saccardo umber and sayal brown, flecked with whitish; sides of neck olive brown with dull buffy white edges, chin and throat, brownish black, becoming more brownish posteriorly, and the feathers everywhere with buffy or tawny squamate edges; crissum and thighs between ashy brown and saccardo umber, streaked with buffy whitish; lower breast, abdomen, sides, and flanks, grayish white, streaked and mottled with smoke gray; edge of wing brownish black; lining of wing pinkish buff, anteriorly cinnamon buff.

Measurements of type.—Wing, 49 mm.; tail, 42.5; exposed culmen, 10.5; tarsus, 16; middle toe without claw, 11.3.

***Uroloncha acuticauda phaethontoptila*, subsp. nov.**

Subspecific characters.—Similar to *Uroloncha acuticauda squamicollis*, from China,^{*} but upper parts, chin, and throat, lighter, more rufescent; jugulum, upper breast, sides of head and of neck, lighter, posterior lower surface less distinctly streaked.

Type.—Adult, No. 37817, U. S. Nat. Mus.; northern Formosa, March, 1862; H. B. Tristram.

Measurements of type.—Wing, 48 mm.; tail, 39; exposed culmen 10.3; tarsus, 13; middle toe without claw, 11.5.

Formosan individuals of *Uroloncha squamicollis*, which is a subspecies of *Uroloncha acuticauda*, are sufficiently differentiated to be considered representative of a different subspecies. Whether or not this race occurs elsewhere than on the island of Formosa our material does not show.

***Munia maja simalurensis*, subsp. nov.**

Subspecific characters.—Similar to *Munia maja leucocephala* from Sumatra, but anterior lower parts lighter.

Description.—Type, adult male, No. 179369, U. S. Nat. Mus.; Simalur Island, Barussan Islands, western Sumatra, November 22, 1901, Dr. W. L. Abbott. Head creamy white; rest of upper parts walnut brown, upper tail-coverts metallic claret brown; tail dark vinaceous drab, with edges of metallic claret brown; wings between fuscous and benzo brown, the tertials and the external edgings of the rest of the wing feathers walnut brown like the back, the edge of wing lighter, chin white; throat vinaceous buff, jugulum dull wood brown; middle of breast, middle of abdomen, together with the flanks and crissum, brownish black; sides of breast and of body rather light walnut brown; lining of wing and inner edgings of the secondaries cinnamon buff.

Measurements of type.—Wing, 52.5 mm.; tail, 33; exposed culmen, 11.5; tarsus, 15; middle toe without claw, 14.

This race is known from only Simalur Island.

***Munia maja zapercna*, subsp. nov.**

Subspecific characters.—Similar to *Munia maja leucocephala*, from Sumatra, but larger, with upper parts darker, less rufescent; and with lower parts darker.

^{*} Type from Chingchow, Szechuan, China (C. CHUANG, *in litt.*).

Type.—Adult male, No. 220192, U. S. Nat. Mus., Sawarna, Wynkoop's Bay, Bantam, Java, November 2, 1909; William Palmer; original number, 1944.

Measurements of type.—Wing 56 mm.; tail, 39; exposed culmen, 12; tarsus, 16; middle toe without claw, 15.

This subspecies may be distinguished from *Munia maja simalurensis*, of Simalur Island, western Sumatra, by its larger size, and darker, less rufescent coloration, both above and below.

With the above-made additions, the recognizable subspecies of *Munia maja* are:

1. *Munia maja maja* (Linnaeus). Malay Peninsula.
2. *Munia maja leucocephala* (Raffles). Sumatra and the island of Nias.
3. *Munia maja simalurensis* Oberholser. Simalur Island, Barussan Islands, western Sumatra.
4. *Munia maja zapercna* Oberholser. Java.

ETHNOGRAPHY.—*Source of the name Shasta*.¹ C. HART MERRIAM, Washington, D. C.

The source of the name Shasta seems to have been long overlooked. Stephen Powers failed to learn anything about it, and was equally unsuccessful in his attempt to ascertain the name by which the Shaste Indians designate their own tribe.²

Roland Dixon, in his valuable work on the "Shasta" (1907) says of the name, that its origin and meaning "are both obscure," and even suggests that it may have been derived from the name of an old man "whose personal name was Shastika (Süst'ka)." At the same time Dixon was aware that the name was "in use by both *Achomá'wi* and *Atsugé'wi*," but for some unknown reason concluded that "it is not a term for the Indians of this stock [Shastan] in the languages of the surrounding stocks."³ Nevertheless Gatschet, in his Klamath Dictionary, published in 1890, specifically states that the Klamath name for the Shaste is *Shasti* (alternate *Sasti*), and adds that "the usual form *Shasta* is a corruption of *Shasti*."⁴ And, as well known, the Klamath tribe (*Lutuame*) adjoins the Shaste tribe on the east.

¹ Received September 15, 1926.

² POWERS, *Tribes of California*, p. 243, 1877.

³ DIXON, ROLAND B. The Huntington California Expedition, *The Shasta*. Bull. Amer. Mus. Nat. Hist. 17: (Pt. 5) 384, July, 1907.

⁴ GATSCHET, A. S. *Dictionary of the Klamath Language*, p. 290, 1890. Gatschet gives the forms *Sasti* and *Shasti* as interchangeable, adding that the Klamath Lake people call the members of the Shasti tribe *Sdsetiam maklake*.

The name given me for the Shaste by the Pit River Achomawe is *Sas-té'-che* (alternate *Shas-té'-che*).

But Dixon's paper was published three years before the publication of Peter Skene Ogden's "Snake Expedition Journal" of 1826-1827 in which the matter is settled once for all. Peter Ogden, one of the most indomitable and determined of the remarkable series of leaders of the Hudson Bay Fur Company's explorers and trappers, spent a couple of months in the pursuit of beaver in the Klamath Lakes country, after which he moved westerly or northwesterly to the upper waters of Rogue River, where, under date of Feb. 10, 1827, his Journal contains the following entry: "Here we are among the Sastise. Course this day west. The stream we are on [Rogue River] has no connection with the Clammitte River [Klamath]; it flows south then west to a large river. These Indians know nothing of the ocean."⁴

Four days later he writes: "I have named this river Sastise River. There is a mountain equal in height to Mount Hood or Vancouver, I have named Mt. Sastise [Mt. Pitt, west of the main Klamath Lake]. I have given these names from the tribes of Indians."⁵

Under date of March 9 he spells the name *Sasty*, saying: "At early hour with aid of 2 small canoes crossed over Sasty River, all safe over by 4 P.M." And again, on the 13th: "We left the Sasty Forks in our rear."⁶

The earliest appearance of the name in print, so far as known, as in Arrowsmith's "Map of British North America" published in 1832 (2d ed. 1834, in J. Arrowsmith's London Atlas). This map shows "*Shasty River*" well north of the "*Clamel*" [Klamath], occupying the course of the turbulent stream now known as Rogue River. Charles Wilkes in his "Map of the Oregon Territory," 1841, follows Arrowsmith in adopting Ogden's name *Sasty* (but spelling it *Shaste*) for Rogue River. The same is true of Gallatin's "Ethnographical Map of Oregon" [1848]⁷ from Hale's "Ethnology of the American [Wilkes] Exploring Expedition."

T. C. Elliott, in an editorial footnote on page 213 of Ogden's Journals, mistakes the Shasty River of Ogden and Wilkes (which is in Oregon) for Pit River (incorrectly spelled Pitt) which is in California.

That the upper part of Rogue River is the *Sastise* (or *Sasty*) River of Ogden is obvious not only from Ogden's own account of his move-

⁴ OGDEN, PETER SKENE. *Snake Expedition Journal, 1826-1827*. (As copied by Miss Agnes C. Laut in 1905 from original in Hudson's Bay Co. House, London, England.) Quarterly, Oregon Historical Soc., 11: (No. 2) 213, June, 1910.

⁵ Ibid., p. 214.

⁶ Ibid., p. 216.

⁷ Trans Amer. Ethnological Soc., New York, vol 2, 1848

ments but also from the maps of Arrowsmith (1832 and 1834), Wilkes (1841), and Gallatin (1848), this part of which is avowedly based on information from Ogden.

In 1835, Michel L. Framboise, a French-Canadian trapper and interpreter, gave Dr. Gairdner, then stationed at Fort Vancouver, a list of Indian tribes which includes both "*Clamet*" and "*Sasty*." Of the location of the latter tribe he says, "On a river of the same name to the west of No. 30. [No. 30 is the "*Clamet*."]". La Framboise, in common with other Hudson Bay trappers of the time, was of course familiar with Ogden's names.

Prior to 1851 much confusion existed in relation to the courses of the rivers of southwestern Oregon and northern California. Bonneville's Map of 1837, entitled "The Territory West of the Rocky Mountains," puts the name "*Claymouth*" on Rogue River for its entire course—ten years after it had been named *Sasty* or *Sastise* by Peter Ogden.

Several maps issued in the forties and early fifties show the upper reaches of Klamath River in approximately the correct position, but follow Bonneville, Hale, and others in deflecting the middle course to the northwest, making it a tributary of Rogue River. But B. F. Butler's "Map of the State of California" showing the Gold Region, published in San Francisco in 1851, reverses the usual practice by showing the upper part of Klamath River as rising from the western slopes of Mt. Pitt in Oregon, thus confusing it with the *Sasty* River of Ogden [Rogue River], which is made to flow southwesterly [across the Siskiyou Mountains!] to reach the proper lower course of Klamath River in northern California; while the actual upper part of Klamath River is labeled *Shaste River*!

The earliest map I have examined in which the name Shasta River appears on the stream now known by that name—a tributary to Klamath River from the south—is a manuscript "Sketch Map of the Northwest part of California," drawn by George Gibbs in 1851 (photostat in my possession from original in Indian Office).

It has been shown that the word *Saste* is the Klamath (Lutuami) name for the tribe which since the publication of Hale's "Ethnography" 80 years ago has been commonly known as *Saste* (Shaste, or Shasta). It is known also that Peter Skene Ogden after spending two months among the Klamath Indians in the winter of 1826-1827,

¹ *Notes on the Geography of the Columbia River* by the late Dr GAIRDNER. Journ. Royal Geogr. Soc London, 11: 256, 1841.

and consequently familiar with their name for the adjoining tribe on the west, entered the territory of that tribe and deliberately gave its name to the river on which he found them [now known as Rogue River], and to the great mountain at its head [now known as Mt. Pitt]. It is one of the tragedies of geographic nomenclature that these names, by reason of a break in the continuity of local knowledge of the region, have been transferred to features remote from those upon which they were originally bestowed. Still, it is something to be thankful for—from the standpoint of anthropology—that both the great mountain and the river to which the name was transferred are still within or bordering on the territory of the Shaste tribe.

While the name of the tribe is now firmly established as *Shaste* (or *Shasta*), it should be kept in mind that this is *not* the name by which members of the tribe call themselves. Their name for themselves is *Ge'-kahts* or *Ke'-katch* (once given me as *Gik'-kahich*). Roland Dixon got it in the form *Kikatsik*.

• ARCHEOLOGY.—*Ancient soapstone quarry in Albemarle County, Virginia.*¹ DAVID I. BUSHNELL, Jr., Washington, D. C.

Steatite, often called soapstone, is encountered in many localities from Georgia and Alabama northward through the eastern states to the Canadian boundary and beyond. It was known to the Indians long before the coming of Europeans, and as it was easily quarried with the use of the crudest of stone implements it was obtained and employed by them in making bowls, tobacco pipes, and ornaments of various sorts.

The extent of the use of soapstone by the Indians is indicated by the large number of ancient quarries located in different parts of the region in which it occurs, and seldom are masses of the stone discovered without finding traces of their work—evidence of the use of stone tools on the exposed surfaces. But necessarily such sites vary greatly in size, and although the more extensive were probably visited and revisited through generations others were far less important and appear to have furnished material for very few objects.

A quarry of much interest, one where many soapstone vessels had been made by the Indians, was discovered some years ago when Connecticut avenue, in the city of Washington, was opened, about one half mile north of the present bridge over Rock Creek. This was quite similar to others at that time known to exist in different parts of

¹ Received October 5, 1926.

the country, many of which were described by Holmes in the Fifteenth Annual Report of the Bureau of Ethnology, Washington, 1897. Other quarries have been discovered since that time, including the one which forms the subject of this note.

Soapstone is found in many parts of the piedmont section of Virginia and in recent years has been quarried extensively in Albemarle and Nelson Counties, localities where it had been obtained by the Indians generations ago, probably long before the settlement of Jamestown. When that part of Virginia first became known to Europeans it was claimed and occupied by Siouan tribes belonging to the Monacan group or confederacy, and one of their most important villages, *Rasawek*, was situated on the banks of the James at the mouth of the Rivanna, some distance to the eastward. But undoubtedly other tribes had occupied or frequented the region before the Siouan people had reached the country east of the mountains, and consequently it is not possible to identify the workers of the ancient quarries.

Very extensive quarries are now being operated by the Virginia Alberene Corporation in the vicinity of Schuyler, Nelson County, and another is about to be opened some two miles in a direct line north of east from Schuyler, on a high ridge a short distance south of Damon in Albemarle County, between five and six miles northwest from the



FIG. 1.—(U S. N. M. 332,023) Unfinished bowl, showing knob at ends, $\times \frac{1}{4}$ dia.

nearest point on the James. Through the courtesy of Mr. H. N. Covell, of the Corporation, I was enabled during the past summer to make several visits to this very interesting site. Here great masses of soapstone, outcropping on the surface, follow the general direction from southwest to northeast and have a dip of about 60° to the southeast. The area is heavily timbered, the surface very irregular and broken, with one or more springs near by. For a distance of nearly a thousand feet along the ridge it is possible to trace pits dug by the Indians, generations ago, when getting soapstone. More than twenty

excavations were discovered, the majority being within the northern half of the distance, and becoming less clearly defined southward. They vary in diameter from ten to thirty feet and at present are from two to four feet in depth, some are distinctly separated while others merge and may in reality be parts of a greater excavation. The surface surrounding the pits is covered with pieces of stone which had evidently been rejected and thrown from the quarries, but now all is covered with thick vegetal mold, the spaces between the pieces are filled, and very little of the stone is visible between the mold and moss. The ancient pits are similarly covered and consequently it was not possible to ascertain the actual extent of the quarries.



FIG. 2.—(U. S. N. M. 332,025) Part of a flat-bottomed vessel, $\times \frac{1}{4}$ dia.

The site gives the appearance of great age and centuries have probably elapsed since it was last worked by the Indians. Many broken vessels have been discovered in the vicinity of the pits, all broken in the process of making and abandoned as useless, but such pieces now prove of interest as they show the marks of the crude stone implements on the rough, unfinished surfaces, and thus reveal the manner in which the vessels were made. The majority appear to have been oval in form with knobs projecting from the narrower ends to serve as handles, a type of vessel which was evidently made extensively in Virginia and Maryland, but of which no finished example is known to exist.

Typical examples of fragments of unfinished bowls collected on the site, in the vicinity of the pits, are shown in the accompanying sketches.

Figure 1 represents a large specimen, very rough, measuring about 17 inches in length. One side had been broken but the knobs remain at both ends. This would probably have had a flat bottom.

Figure 2 shows part of a flat-bottomed bowl with rather straight sides. Handles project from the upper edge as in the preceding.

Two forms of bowls were made, as indicated by the fragments, one had a flat bottom with handles projecting from the upper edge, as represented in figures 1 and 2. The second type may have been

smaller, the bottoms were rounded and the handles extended from the sides an inch or more below the rims.

Figure 3 shows a fragment of a rather small vessel with rounded bottom and sides. The surface was probably finished, ready to be smoothed or polished when broken.

Several quartz implements, used in working the soapstone, were discovered on the surface near one of the northernmost pits. One



FIG. 3.—(U. S. N. M. 332,024). Fragment of a round-bottomed vessel, $\times \frac{1}{2}$ dia.



FIG. 4.—(U. S. N. M. 332,027). Crude quartz tool, $\times \frac{1}{2}$ dia.

example, a very crude tool which may have been used in preparing the insides of vessels, is shown in figure 4.

Much work was done at this interesting site, quantities of soapstone were removed from the pits and innumerable objects, both large and small were made, but very few have ever been recovered from village sites, mounds or burials.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 16

DECEMBER 3, 1926

No. 20

GEOPHYSICS.—*The tides on the north Siberian shelf: their bearing on the existence of land in the Arctic Sea, and their dynamics.*¹
H. U. SVERDRUP. (Communicated by **W. J. PETERS.**)

The study of the Arctic tides attracted wide attention when the late Dr. Rollin A. Harris of the United States Coast and Geodetic Survey in 1911 concluded from his investigations that there was an extensive area of land within the unexplored area of the Arctic region. This conclusion was contrary to that of Fridtjof Nansen whose studies of the oceanography of the part of the Arctic Sea which he traversed with the **FRAM** during 1893 to 1896 had led him to believe in the existence of a deep polar basin.

Since Harris' conception became known the hypothetical Harris Land loomed before the eyes of the explorers who made it their task to solve one of the last of the geographical riddles of the globe, but their search was fruitless. McMillan, on his Crocker Land Expedition, and Stefansson, on his remarkable journeys over the sea-ice north of Alaska, both touched the outskirts of the unknown region without finding anything but broken sea-ice. Apparently Harris was wrong in his conclusion. However, the available data from the wide region west of Alaska and from the great north Siberian shelf were very scanty in 1911; there was practically only one tide-station, viz., Bennett Island. It was chiefly from the observations at this station that Harris drew his bold and far-reaching conclusions. Since 1911 new information has been gathered from this region, mainly through the work of the **MAUD** expedition in the years 1918-1925. The **MAUD** spent four years at various places on the coast of northern Siberia and drifted for two years with the ice distant 400 miles from the coast.

¹ Presented before the Philosophical Society of Washington, October 2, 1926. Received for publication Oct. 13, 1926.

The investigation of these observations combined with the earlier data indicated a tidal wave differing entirely from that deduced by Harris and led to the conclusion that the tidal phenomena do not indicate the existence of any extensive masses of land within the unexplored area. This conclusion was first mentioned in a radio message from the MAUD in 1923 and was further confirmed by the observations in 1924-1925. It was proved to be correct when in May 1926, Captain Amundsen, Lincoln Ellsworth, and General Nobile crossed from Spitzbergen to Alaska in the dirigible *NORGE* and passed over the central part of the unexplored area without seeing any land.

Figure 1 shows the available data for conditions at spring-tide for the entire region; spring-tide conditions were used since the most

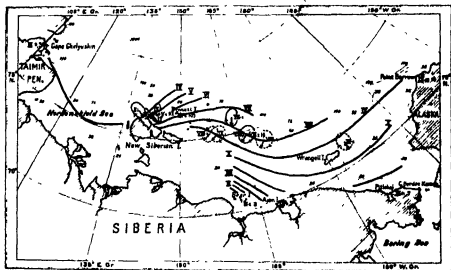


Fig. 1.—Tidal observations and co-tidal lines at spring tide on the north Siberian shelf.

reliable observations on the open shelf are obtained around spring-tide, when the difference between high-water and low-water is greatest and the tidal currents are most strongly developed. The earlier data indicated were obtained at Point Barrow (Alaska), Pitlekaj, and Bennett Island, while all the others result from the work of the MAUD expedition. The MAUD work was at the coast stations Cape Chelyuskin, Bear Islands, and Ajon Island, at three offshore stations where the time of high-water and the rise of the tide were determined by soundings, and at nine stations where the tidal currents were examined. The directions of the maximum tidal currents at spring-tide are plotted as arrows and the times of maximum current are expressed

in Greenwich lunar time. The characters of the tidal currents are indicated by ellipses, meaning that the currents are rotating; the directions in which the currents rotate are indicated by arrow-heads. The ratio between the axes of each ellipse is equal to the ratio between maximum and minimum currents. The ellipses when full drawn represent the mean current from the bottom to the surface; when dashed they represent the current at selected levels. The time of high-water is given at all stations in terms of Greenwich lunar time. A line joining the points where spring high-water occurs at the same Greenwich lunar time represents the crest of the tidal wave at this particular time, a co-tidal line at spring. These lines, furthermore, have been drawn so that they run perpendicular to the directions of maximum currents. The heavy black lines represent the co-tidal lines drawn according to these rules. They represent the observations in a very satisfactory way and it can not be doubted that the co-tidal lines in this figure actually represent the front of the tidal wave at the stated hours.

What conclusions can be drawn from this picture regarding the existence or non-existence of land within the Arctic? Harris from his discussion concluded that the tidal wave proceeded from Bennett Island to Point Barrow, that is, practically from west to east and that this course necessitated the existence of an extensive area of land. Our result shows that the wave does not proceed from west to east but that it enters the entire region from the north. The tidal wave has the same character as the tide of the northern Atlantic. Therefore it can not be doubted that the tidal wave from the northern Atlantic enters the opening between Spitzbergen and Greenland and crosses the Arctic Sea without meeting any obstruction formed by extensive masses of land. However, no definite conclusion can be drawn that smaller islands may not exist. The figure reveals the striking fact that the tidal wave reaches the region of De Longs Islands five hours before it reaches Point Barrow though the direct distance from the Spitzbergen opening is nearly the same in both cases. This would indicate strongly that the sea is more shallow between Point Barrow and the Pole than between De Longs Islands and Spitzbergen, indeed perhaps so shallow that we might expect islands-in places; however, any such conclusion may not be definitely drawn because we do not know enough about the progress of a long wave across a deep sea. The only certain conclusion, therefore, is that no extensive masses of land exist and this conclusion has already been verified by the results of the flight of the *NORGE*.

The co-tidal lines in our figure combine, as already mentioned, all observations in a satisfactory way and, together with the curves showing the motion of the water-particles, give a complete picture of the wave which enters the shelf from the north. In dealing with the tidal waves on the continental shelves one may neglect the direct action of the tidal producing forces, because this is proportional to the body of water upon which the forces act and the body of water on the shelves is negligible compared to that of the large oceans. Generally it is assumed that the tidal waves proceed across the continental shelves under the action of gravitational forces only. However, the picture in Figure 1 deviates greatly from that of a long wave proceeding under the influence of gravitational forces only. Attention may be drawn to the main characteristics as follows:

(1) The tidal currents do not run alternately in the direction in which the wave proceeds or against this direction but within the whole region they rotate clockwise. Over the open shelf there is very little difference between the strongest and the weakest currents, but where the wave runs parallel to a coast the currents are almost alternating.

(2) The currents are not uniform from the bottom to the surface. This is not evident from the entries in this figure, but we shall later return to this very important fact.

(3) The velocity of progress of the wave does not stand in the simple relation to the depth which is characteristic for a gravitational wave.

(4) The range of the wave varies within wide limits, from 210 cm. north of the New-Siberian Islands to only 3 cm. at Bear Island. A closer inspection shows that the range varies both along and perpendicularly to the wave-front. Referred to the direction in which the wave proceeds the range decreases from right to left, from 210 cm. to 14 cm. between the New-Siberian Islands and Point Barrow and it also decreases in the direction of progress, for instance from 18 cm. 400 miles off the coast to 5 cm. at Ajon Island and to 3 cm. at Bear Island.

All these features can be explained if the effect of the forces of inertia arising from rotation of the Earth and the resistance due to the eddy-viscosity are taken into account. I shall show how this can be done in the present case.

The upper left equations in figure 2 represent the hydrodynamic equations for a long gravitational wave. The X-axis of the coordinate system has been placed in the direction of progress of the

wave, and u and v represent the velocities of the water-particles in and perpendicular to the direction of progress, respectively. The elevation of the wave above the normal level is called ζ , the depth is called h , and the acceleration of gravity is called g . The two upper equations show that the only gravitational forces are acting upon the particles while the third equation represents the equation of continuity.

HYDRODYNAMIC WAVE EQUATIONS FOR A NON-VISCOUS FLUID ON A RESTING OR ROTATING DISC, AND SOLUTIONS

Quantity	V a l u e s f o r		
	Resting disc or channel	Rotating channel	Rotating disc
$\frac{\partial u}{\partial t}$	$-g \frac{\partial \zeta}{\partial x}$	$-g \frac{\partial \zeta}{\partial x} + 2uv$	$-g \frac{\partial \zeta}{\partial x} + 2uv$
$\frac{\partial v}{\partial t}$	0	$-g \frac{\partial \zeta}{\partial y} - 2au$	$-2au$
$\frac{\partial \zeta}{\partial t}$	$-h \frac{\partial u}{\partial x}$	$-h \frac{\partial u}{\partial x}$	$-h \frac{\partial u}{\partial x}$
ζ	$\zeta_0 \sin (\sigma t - yx)$	$\zeta_0 e^{-\frac{2\sigma}{c} y} \sin (\sigma t - yx)$	$\zeta_0 \sin (\sigma t - yx)$
u	$\frac{g}{\sigma} \zeta_0 \sin (\sigma t - yx)$	$\frac{g}{c} \zeta_0 e^{-\frac{2\sigma}{c} y} \sin (\sigma t - yx)$	$\frac{g}{\sigma} \zeta_0 \frac{\sigma^2}{\sigma^2 - 4\omega^2} \sin (\sigma t - yx)$
v	0	0	$\frac{2\omega}{\sigma} \frac{g}{c} \zeta_0 \frac{\sigma^2}{\sigma^2 - 4\omega^2} \cos (\sigma t - yx)$
c	$\sqrt{gh}$	$\sqrt{gh}$	$\sqrt{gh} \sqrt{\frac{\sigma^2}{\sigma^2 - 4\omega^2}}$

Fig. 2—Hydrodynamic wave equations for a non-viscous fluid on a resting or rotating disc, and solutions

The first column in the lower part of figure 2 gives a solution of above equations. If the deformation of the surface is represented by a simple sine function, then the velocities of the particles will be directed alternately in the direction of progress or against the direction of progress of the wave, the maximum velocity being reached when the wave reaches maximum height. No transversal velocities ($v = 0$) are developed. The wave itself proceeds with a velocity $c = \sqrt{gh}$.

A wave proceeding in an infinitely long rotating channel does not differ very much from the wave here considered. The hydrodynamic equations are more complicated because we now have to add the terms which represent the so-called Coriolis's force, namely, the

force of inertia which arises on account of the rotation. The solution of these equations derived by Lord Kelvin is given in the lower part of figure 2. We find now that the amplitude of the wave varies across a section of the channel. The effect of the rotation is evidently to press the wave towards one side of the channel, the forces of inertia arising from the rotation being balanced by a slope of the wave-crest. The velocities of the water-particles are still alternating and the velocity of progress is equal to the square root of gh . These waves can be represented schematically by a simple figure as in figure 3

$$S = 0$$

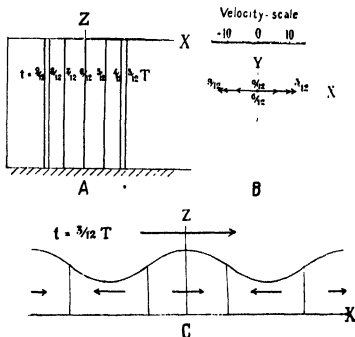


Fig. 3—Schematic representation of a long wave in a non-viscous fluid on a rotating disc or in a rotating channel.

where A is to represent a vertical section showing the velocities of the particles in the direction of progress. It is seen that these are uniform from the bottom to the surface. B shows that the velocities are alternating. C shows a section of the wave with the vertical dimensions extremely exaggerated.

The hydrodynamic wave-equations can also be given a solution with a definite physical meaning when referred to conditions on an unlimited rotating disc. This solution is found in the lower right

part of figure 2. The wave itself is now supposed to have the same character as on a resting disc, the elevation above normal level being supposed to vary in the direction of progress only. The velocities of the particles will then become rotating as is evident from the equations for u and v . The velocity of progress of the wave is also modified becoming greater than on a resting disc. It may here be remarked that the given solution is valid only as long as σ , the frequency of the wave, is smaller than 2ω , the double angular velocity of the disc. Waves of the type here dealt with cannot exist on a rotating disc if this condition is not fulfilled.

The meaning of these results can also be expressed in another way. On a resting plane the orbit of inertia is a straight line but on a rotating disc the orbit of inertia referred to a coordinate system which takes part in the revolution is a circle. The time required for one complete revolution in the circle of inertia is equal to half the time required by the disc for one revolution. If a wave proceeds across a rotating disc we will meet a phenomenon of resonance between the gravitational oscillation and the oscillation in the circle of inertia. The particles will no longer describe straight lines back and forth, but will describe ellipses which will become larger and larger and approach circles more and more as the periodic length of the wave approaches half the time required by the disc for one revolution. At the same time the wave-length will increase, or since the periodic length is assumed to remain constant, the velocity of progress will increase.

On a resting disc one-half of the energy of the wave is present as kinetic energy, the other half as potential. On a rotating disc the forces of inertia tend to preserve the kinetic energy and on an unlimited disc where this tendency is unhindered by boundaries the major part of the energy of the wave will be present as kinetic.

These conditions are represented graphically in figure 4. The vertical section shows that the motion still is uniform from the surface to the bottom, while the horizontal section B shows that the velocities have a rotating character.

These two solutions, which are valid for a wave in an infinitely long rotating channel and on an unlimited rotating disc, represent the fundamentals for the discussion of the influence of the Earth's rotation on the tidal wave. We have now to discuss the influence of the eddy-viscosity. It is well known that the viscosity of water is far too small to affect the currents in the sea, but it is also known that if the motion of a fluid is turbulent, then an exchange of mass

damped wave, the amplitude decreasing in the direction of progress. The velocities are still rotating but depend upon the vertical coordinate, z ; the velocity of progress, c , which can be computed by means of the last equation, is no longer a simple function of the depth but depends also upon the eddy-viscosity. The complex constants C_1 to C_4 have to be determined by the boundary-conditions. Figure 6 illustrates the conditions under certain assumptions. From the vertical section A it is seen that the motion is not uniform from the surface to the bottom. The velocity increases from the bottom

HYDRODYNAMIC WAVE EQUATIONS FOR A VISCOUS FLUID ON A ROTATING DISC,
AND THEIR SOLUTIONS

$$\frac{\partial u}{\partial t} = -g \frac{\partial \zeta}{\partial x} + 2\omega v + \eta \frac{\partial^2 u}{\partial z^2}$$

$$\frac{\partial v}{\partial t} = -2\omega u + \eta \frac{\partial^2 v}{\partial z^2}$$

$$\frac{\partial \zeta}{\partial t} = -\int_0^h \frac{\partial u}{\partial x} dz$$

$$\zeta = -1 \int_0^h e^{-\gamma z} e^{i(\sigma t - \gamma x)} dz$$

$$u = \frac{g}{\sigma^2 - 4\omega^2} e^{\frac{\gamma}{2} z} e^{-\gamma x} (p+1) \left\{ C_1 e^{(1+i)\beta_1 z} + C_2 e^{-(1+i)\beta_1 z} + C_3 e^{(1+i)\beta_2 z} + C_4 e^{-(1+i)\beta_2 z} - \sigma \right\} e^{i(\sigma t - \gamma x)}$$

$$v = 1 \frac{g}{\sigma^2 - 4\omega^2} e^{\frac{\gamma}{2} z} e^{-\gamma x} (p+1) \left\{ -C_1 e^{(1+i)\beta_1 z} - C_2 e^{-(1+i)\beta_1 z} + C_3 e^{(1+i)\beta_2 z} + C_4 e^{-(1+i)\beta_2 z} - 2\omega \right\} e^{i(\sigma t - \gamma x)}$$

$$\frac{g}{\sigma^2 - 4\omega^2} e^{\frac{\gamma}{2} z} (p+1) \int_0^h \gamma^2 dz = 1$$

$$c = \frac{h}{T} = \frac{g}{\mu}, \quad p = \frac{T}{\mu}$$

Fig. 5—Hydrodynamic wave equations for a viscous fluid on a rotating disc, and their solutions.

and up and in the vicinity of the bottom the maximum velocity is reached at an earlier moment than at a greater distance from the latter. The horizontal sections for two levels show that the velocities have the rotating character in both levels, but nearer to the bottom the ellipse which joins the ends of the vectors is narrower and turned to the right when referred to orientation of the upper ellipse.

When applying the results of these theoretical considerations to the tidal phenomena on the north Siberian shelf we must remember that the results, strictly speaking, are valid only for waves in a fluid of constant depth and of constant eddy-viscosity on an unlimited rotating disc whereas actual conditions involve a limited region on a rotating sphere with the depth and the eddy-viscosity subject to great variations. Despite this the main features are readily recognized.

Returning to figure 1 we find that the perfect development of the rotary currents at great distance from the coast and the dwindling of the transversal currents, where a coast to the right of the wave prevents their development, is in agreement with what we should expect. The great velocity of progress where the currents are rotating and the small velocity where they are alternating is also in agreement. The great range of the tide which we find where the wave

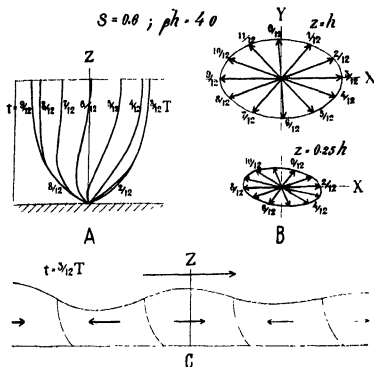


Fig. 6.—Schematic representation of a long wave in a viscous fluid on a rotating disc

rolls along a coast is the result of the wave being pressed against the coast by the deflecting force of the Earth's rotation, while the decrease of the range which accompanies the development of the rotary currents tells that the action of the forces of inertia here tend to preserve the major part of the energy as kinetic. The decrease of the range in the direction of progress is due to the dissipation of the energy through the eddy-viscosity.

I have mentioned that the tidal currents showed great variations with depth. As an example I shall show the currents observed in the central part of the shelf. The upper part of figure 7 shows observed tidal currents. The vertical section A represents the com-

ponent of the currents in the supposed direction of progress. The ice took no part in the tidal movement and down to 35 meters the

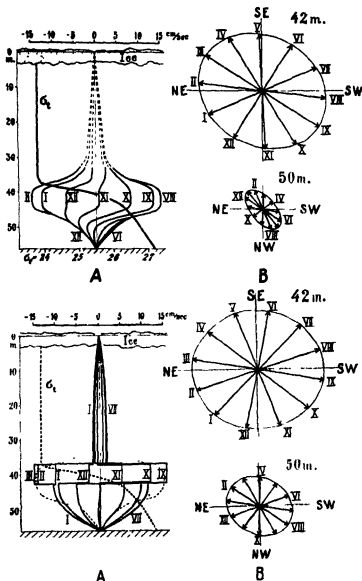


Fig. 7.—Examples of tidal currents observed on the north Siberian shelf (upper part) and theoretically computed tidal currents (lower part).

currents were too weak to be observed. Under this level we found strong tidal currents which again rapidly decreased towards the

bottom. The two horizontal sections show that the currents were rotating in all depths but close to the bottom the ellipse was narrower and turned to the right referred to the ellipse of the upper layer. There is evidently a close relation between the distribution of the density and the development of the tidal currents. The density is indicated by the heavy curves marked σ_t . It is seen that the density remains constant from the ice down to 38 meters, after which we find a sudden and very rapid increase and later a slow increase as we approach the bottom. Where the density is constant we must expect a very great eddy-viscosity because the conditions for formation of eddies are here very good but where the density increases rapidly with depth the eddy-viscosity must be small because vertical eddies can not be developed. We can therefore consider the water as formed of three layers of different eddy-viscosity and on this assumption we can compute the tidal currents by means of the general equations. The result of the computation is represented graphically in the lower part of figure 7. The computed currents differ naturally from the observed, partly because the theory supposes discontinuous transitions from one layer to another while these transitions in nature are continuous. However, the main features agree so well that it can not be doubted that rotation of the Earth and the varying eddy-viscosity are the factors which are responsible for the peculiar currents which were observed.

Summing up it can be said that the tidal wave on the north Siberian shelf has all the characteristics of a long gravitational wave in a viscous fluid on a rotating disc.

The theoretical considerations which have been sketched here naturally may find application to the tidal phenomena on other continental shelves and, in addition to those carried out by other investigators as Taylor, v. Sterneck, and Defant, serve to give a better understanding of the laws according to which the tidal waves cross the continental shelves before reaching the coast. This knowledge is indispensable for the whole theory of the tides. We must know how the wave proceeds over the shelf in order to find the character of the wave at the moment it reaches the border of the shelf. And the facts regarding the character of the tides at the borders of the continental shelves are those with which we must test any theory dealing with the fundamental but exceedingly difficult problem, namely, the creation of the tidal waves in the big oceans under the action of the tidal creating forces.

BIOLOGY.—*A time recorder for quantitative work in animal behavior.*¹ RAYMOND PEARL, Institute for Biological Research of the Johns Hopkins University.

The piece of apparatus shown in figure 1 has been constructed for use in connection with certain problems regarding the normal behavior and activity of *Drosophila melanogaster*, which are being studied in this Institute. It has proved so useful in practice, and has so many obvious applications in various sorts of biological research, that a brief description of it seems warranted.

The essential element of the apparatus is a 15 pen "Strip chart electric operation recorder" made by The Bristol Company of Waterbury, Conn. This instrument draws a ruled strip of paper, by means

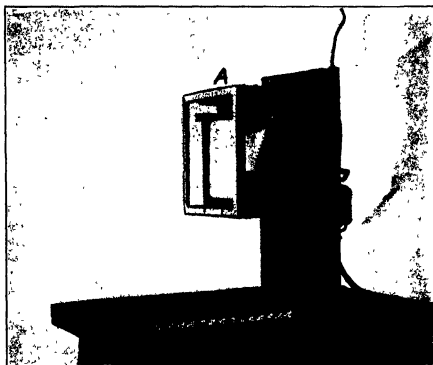


Fig 1—Apparatus for recording time relations in animal behavior studies. A, strip chart electric recorder B, base board C, row of radio switches

of an accurate clockwork, under the 15 pens at a constant rate of speed. By suitable adjustments of the mechanism this rate may be as slow as one inch per hour, or as fast as 6 inches per minute, with a

¹ Received Oct. 26, 1926.

number of intermediate speeds. Each pen is controlled by a small relay magnet, in such a way that when a current is passed through the coil of the magnet the end of the pen is drawn about 1 mm. to the side of its normal resting position. In the apparatus shown in figure 1, each of the pens of the operation recorder has been wired to a small radio switch set in the base board. Therefore the path of each pen is controllable separately by throwing the appropriate switch in this series.

The manner in which we have used the apparatus is this. On a strip of white adhesive tape alongside the row of switches are written catchwords for the different categories of activity in which a *Drosophila* indulges, such as "flying," "walking," "cleaning forelegs," etc. The switch opposite each such designation is devoted to the recording of that particular kind of activity. A glass beaker or jar, with internal arrangements suitable to the experiment in progress, and containing the fly (or flies) to be observed, is placed upon a stand on the base board. The condition of the room in respect of light, temperature, and quiet, is made suitable to the obtaining of normal results. The observer, having started the strip recorder in motion, then watches the fly. As any particular sort of activity on its part is entered upon, the observer throws the corresponding switch and leaves it on until the fly stops that kind of activity and starts some other, complete rest being regarded, for purposes of record, as a form of activity. When there is a change in the kind of activity the previously thrown switch is returned to normal and at the same time the appropriate new switch thrown on. When an observation period of an hour or two is completed, the clock-work is stopped. After the ink has been given about 24 hours to dry, the strip may be removed from the roll, and the amount of time spent in the different forms of activity determined from the pen records. In practice we have found it desirable to calibrate the apparatus against an accurate stop watch, and measure the pen lines on the paper strip with a millimeter rule, rather than to depend upon the rulings printed on the paper and the stated clock rate.

The dimensions of the apparatus shown in figure 1 are as follows: Length of base board, 86 cm.; width of base board, 51 cm.; height of upright, 60 cm.; width of upright, 29 cm.

On the back of the upright board are a resistance box, a knife switch in the lead-in line, and a fuse block. These are merely for the purpose of establishing a safe connection with the lighting circuit of the laboratory.

Besides the use of this apparatus described in detail above we have employed it for various other physiological and behavior observations, in which it was essential to record the time relations. It would seem to have a wide range of applicability in biological work.

GENETICS.—*Triploid citrus*.¹ A. E. LONGLEY, Bureau of Plant Industry. (Communicated by G. N. COLLINS.)

The work of producing new types of citrus fruits by hybridization is seriously handicapped by the presence of nucellar embryos in the seed. Swingle's² early work showed that many citrus hybrids produce only apogamic progeny when selfed. More recently Frost³ in his genetic studies of citrus seedlings finds that a large percentage of his plants from both selfed and crossed seed prove to be of apogamic origin. These apogamic individuals are merely reproductions of the seed parent. This prevalence of polyembryony necessitates the growing of many valueless seedlings almost to maturity in order to distinguish the asexual forms from the desired hybrids. Therefore any method that will distinguish the true hybrids from the asexual forms at an early stage is valuable.

Recently much interest has been awakened in the plant groups with varying chromosome numbers and citrus has recently been found to possess a few individuals with double the usual chromosome number. In most citrus forms the haploid number is 9, but Frost⁴ has shown that tetraploid plants occasionally appear among seedling citrus, and Longley⁵ found that the Chinese kumquat, *Fortunella hindsii*, has 18 as its reduced chromosome number.

Dr. Swingle of the office of Crop Physiology, Bureau of Plant Industry, called my attention to the prevalence of sterility in triploid plants. This caused him to hope that new seedless varieties of citrus might appear in this aberrant group. Since a cross between a tetraploid and a diploid should produce triploids, i.e., have a chromosome number intermediate between the two parent forms, a special interest is attached to crosses between this Chinese kumquat or any tetraploid form and the more prevalent diploid citrus.

¹ Received Oct. 16, 1926.

² SWINGLES, W. T. *New types of citrus fruits for Florida*. Proc Florida State Hort. Soc. 23: 36-41, illus. 1910.

³ FROST, H. B. *Polyembryony, heterozygosis and chimera in citrus*. Hilgardia 1: 365-402, illust. 1926.

⁴ FROST, H. B. *Tetraploidy in Citrus*. Proc Nat Acad. Sci. 11: 535-537, illus. 1925.

⁵ LONGLEY, A. E. *Polycary, polyspory and polyploidy in citrus and citrus relatives*. Journ. Wash Acad Sci 15: 347-351, illus. 1925.

In Dr. Swingle's extensive collection of bigeneric citrus hybrids there were three young plants, the result of crossing a limequat, *Fortunella margarita* $\times$ *Citrus aurantifolia*, with *Fortunella hindsii*. Although to the trained eye there was evidence of a dual parentage, it was realized that they might be the result of nucellar buds. As a means of distinguishing between a true hybrid and a plant of apogamic origin the author attempted a determination of the chromosome numbers in these plants.

The first flower buds that appeared were collected at the stage when the pollen mother cells were undergoing the reduction divisions.

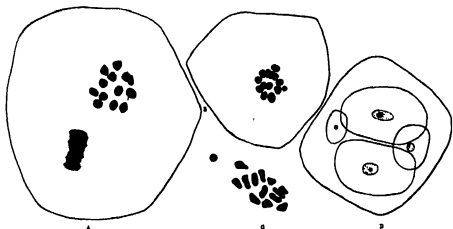


Fig. 1—Pollen development in limequat (*Fortunella margarita* $\times$ *Citrus aurantifolia*) $\times$ *Fortunella hindsii*. A, Homotypic metaphase, 13 chromosomes showing in one plate ($\times 2000$). B and C, Heterotypic metaphase, 13 bivalent and one univalent chromosome ($\times 650$). D, An abnormal pollen tetrad ($\times 650$). (Figures drawn with the aid of a camera lucida, using a Leitz 1.5 objective, and for A a $\times 18$ ocular, for B, C and D a $\times 15$ ocular. Reduced about $\frac{1}{2}$ in reproduction.)

The anthers were opened in acetocarmine solution and counts were made as soon as the chromosomes were sufficiently differentiated from the surrounding plasma to make determinations possible.

The first counts were made from cells in the metaphase of the homotypic division. Figure 1 A shows one plate with 13 chromosomes. Unfortunately no counts could be made of two plates in the same cell and, although 13 stands intermediate between the diploid and tetraploid numbers, it required additional counts to settle definitely the chromosome number of this plant. Months later other buds from this plant were available and figure 1, B and C, are drawings of the chromosomes in the metaphase of the heterotypic division. Both figures show 13 bivalent and a single univalent chromosome. Such clear figures were not often met with. Frequently the

chromosomes were clumped together into what appeared to be tri-valents, and at other times pairing failed causing several univalents to be present at diakinesis. The chromosomes of citrus are very small and it was almost impossible to distinguish between large bivalent and trivalent chromosomes. It was only from such clear figures as are pictured that satisfactory counts could be made. Many counts, however, have assured me that the plant studied is a trivalent citrus and represents a cross.

A few tetrads were studied (figure 1 D) in order to determine the prevalence of polypory. It was found that about 17 per cent had five and 1.5 per cent had six grains in a pollen tetrad. These counts and the presence of only a small percentage of abnormal appearing grains in mature pollen indicate that very little irregularity in chromosome distribution occurs during meiosis in this triploid plant.

The finding of this triploid hybrid shows that it is possible to produce triploid citrus by appropriate crosses. It is, moreover, hoped that in this or similar crosses the much desired seedless Kumquat will be produced.

BOTANY.—*New species of cotton from Colombia and Ecuador.*¹

O. F. COOK and J. W. HUBBARD, Bureau of Plant Industry.

The wealth of natural forms in the genus *Gossypium* receives further illustration in new types of cotton plants collected recently in several localities on the west coast of South America, in Colombia and Ecuador. The native cottons of this region apparently are not closely related to the series of Mexican species described in this JOURNAL under date of June 19, 1926, but show other peculiar characters not previously recognized among the species of *Gossypium*.

The new features include specializations of the involucre bracts and extrafloral nectaries, as well as of the leaves, bolls and seeds. One of new species has involucre with the margins of the bracts turned outward, so that the buds and young bolls are exposed, while another has very small involucre, and very narrow bracts, with only 3 to 5 teeth. In striking contrast with such involucre, other South American species have very large many-toothed bracts, cordate at base, with broad auricles united along their inner margins or overlapping across the pedicel. Other outstanding features are very large and prominent involucre nectaries, large auriform crests or expanded bractlet-like organs surrounding the base of the calyx, bolls

¹ Received Oct. 16, 1926.

with large numbers of seeds per lock, bolls with only 2 locks, the absence of simple or 3-lobed leaves, and pubescence of simple hairs, instead of the stellate pubescence usual in *Gossypium*. Descriptions of some of these characters, with natural-size photographs of their occurrence in the different species, have been prepared for the Journal of Heredity, to follow the paper on characters of new cottons from Mexico which is being printed in the Journal of Heredity for November, 1926. While most of the tropical cottons are not adapted to conditions in the United States, it is of interest and importance to breeding to know the range of characters represented in the genus.

The need of basing botanical descriptions of cotton plants on the living material, growing under conditions of natural adaptation, as explained in the previous paper, becomes still more obvious after the study of these South American forms. Some of the most striking and distinctive characters could not be recognized or described from dried specimens, though some can be shown in photographs. Several important differences of leaves and involucres must be treated in three dimensions, not merely in terms of size and outline. The pressing of the specimens obliterates some of the most distinctive positional features.

Some of the native cottons of the northern districts of Peru were described by Richard Spruce,² in a paper published in 1865, but the species were not named and apparently are not the same as those here described. No other botanist appears to have observed and recorded the characters of cotton plants in South America from living material.

KEY TO SPECIES HERE DESCRIBED

Involucral bracts very small and narrow, with a strong flexure or stand-off at base and with few marginal teeth, only 3 to 5; bolls mostly 4-locked, nearly round, the apex blunt or retuse, surface nearly uniform light green, the oil-glands deeply immersed in the green tissue; pubescence of simple hairs, seeds fuzzy: *Gossypium trident*.

Involucral bracts large and broad, with a slight basal flexure, marginal teeth numerous, 9 to 19; bolls mostly 3-locked, oval, ovate, or fusiform, acuminate or apiculate, deeply pitted, exposing the black oil-glands distinctly; pubescence of stellate hairs; seeds nearly naked after removal of lint, the fuzz very thin or confined to small tufts or bands

Involucres with small nectaries, located in slight depressions; leaf nectaries small, usually confined to the midvein even on large 7-lobed leaves of the main stalk or vegetative branches; fruiting branch leaves all 5-lobed; bolls oblong-oval, abruptly acuminate, the surface even, the oil-gland punctations small and scattering: *Gossypium quinacre*.

² SPRUCE, RICHARD. *The culture of cotton in northern Peru*, The Technologist, May 1, 1865, pp 431-445

Involucres with large, prominent nectaries; leaf nectaries often large, commonly 3 on large 5-lobed and 7-lobed leaves of the main stalk and vegetative branches; fruiting branch leaves commonly 3-lobed; bolls conic-oval, acuminate, the surface irregular with large pits which are often crowded or confluent.

Involucral bracts with margins strongly everted, exposing the buds and young bolls; seeds with lint confined to the upper half or two-thirds of the surface, and with little or no fuzz except in a short band in the lower part of the lint area: *Gossypium evertum*.

Involucral bracts with plane margins, inclosing the buds and young bolls; seeds with tufts of fuzz at the base or apex.

Inner nectaries large, longer than broad, connected by large auriform processes or crests extending around the base of the calyx; auricles of bract moderately developed, united at base, not overlapping the pedicel: *Gossypium calycotum*.

Inner nectaries broader than long; not connected by processes or crests, rarely subtended by narrow bractlets; auricles of the bracts very large, the inner margins curved inward, overlapping across the pedicel, forming circles around the outer nectaries; bolls ovate-oblong, abruptly acuminate: *Gossypium auritum*.

Gossypium tridens sp. nov.

Plant large and tree-like, about 15 feet in height with an erect trunk 4 inches in diameter at base, light green open foliage, and rather long fruiting branches, the numerous short joints bearing small rounded bolls, often with 6 to 8 bolls on a branch.

Leaves small, simple or with 2 to 5 lobes, usually 3-lobed on vegetative branches and 2-lobed on fruiting branches; simple and 5-lobed leaves very few; lobes rather long, narrow, acuminate; midlobe¹ slightly constricted, upfolded around the sinus; forelobes usually unequal, one often twice as large as the other; auricles very short, the basal sinus open; callus strongly decurrent; surface of leaves entirely glabrous, with a fringe of hairs on the margins and scattering hairs on the larger veins above and below; petioles and young branches rather densely pilose; hairs mostly simple, rarely two or three together, instead of stellate; pubescence very persistent, remaining on the year-old wood; length on the midvein of large 5-lobed leaf 16 cm., on the greatest expansion of auricle 17.5 cm., width on points of forelobes 23 cm., on points of sidelobes 13.5 cm., length of petiole 9.5 cm., leaf nectary single, rather small, with prominent rim, oval or ovate, about 1 cm. from base of vein; stipules fugacious, small, falcate, about 1 cm. long, 1 mm. wide at base those of fruiting branches shorter and broader.

Involucral bracts very small and narrow, sublanceolate, slightly auriculate, with strong flexures or off-sets at base, usually free, but sometimes connected for about 1 mm.; teeth usually 3, sometimes 4 or 5, the median tooth as long or longer than the body of the bract, with one or two small teeth on each side; bractlets not present; pedicels cylindrical, short, solid, triangular only near receptacle. Outer nectaries broadly oval or transverse, sunken; inner nectaries very broadly triangular, often reduced to a transverse slit. Calyx very short, with shallow rounded lobes; flowers not seen.

¹ To designate the successive lobes of the leaves, beginning at the middle, the terms midlobe, forelobes, sidelobes and backlobes are used. The principal veins of the lobes are designated correspondingly as midvein, foreveins, sideveins and backveins.

Bolls small, usually as broad as long, subrotund, abruptly narrowed to a blunt point or with a small apical depression; fissures deeply marked at the tip, the divisions bulging beyond the insertion of the stigma; surface smooth, light green, with shallow punctations, the oil-glands deeply immersed; locks 3 and 4, usually 4, seeds per lock 5 to 7.

Seed small, densely covered with long greenish fuzz; lint white, about 1 inch long, fine and silky, not fluffing out.

Type in U. S. National Herbarium nos 1,282,030, 1,282,031, and 1,282,032 collected from the same plant at Buenaventura, Colombia, May 28, 1928, by O. F. Cook and J. W. Hubbard (no. 169).

The outstanding features of this plant are the small, narrow, free, involueral bracts, the small round bolls, the numerous 2-lobed leaves, and the pubescence of simple hairs.

Gossypium quinacre sp. nov.

Plant moderately robust, about 2 meters high, of rather low, spreading "herbaceous" habit, main stalk short-jointed, bearing numerous short-jointed horizontal vegetative branches, and strong fruiting branches, attaining 85 cm, with rather long basal joints; also with fruiting branches near the ground on the vegetative branches; foliage and general appearance of the plant suggesting Sea Island cotton.

Leaves large, subglabrous, with pale venation, surface strongly upfolded between veins, lobes 5 to 7, with long acuminate points, none of the leaves 3-lobed; the forelobes often equal to the midlobe; auricles large, usually overlapping, midlobes occasionally with teeth, but these confined to a few leaves of the main stalk, the teeth usually above the middle of the lobes; length of large leaf on midvein 23 cm, on greatest expansion of auricle 25 cm, width on points of forelobes, 33 cm., on points of sidelobes 20 cm., length of petiole 16 cm. Leaf nectaries, only 1 on fruiting branch leaves, 1 to 3 on main stalk and vegetative branch leaves, even large 7-lobed leaves sometimes with only 1 nectary; midvein nectaries long, elliptical to lanceolate, located about 2 cm. from base, forevein nectaries very small, ovate, located about 1 cm from base. Petioles papillate with prominent oil-gland. Stipules long, linear, but on fruiting branches sometimes broad and strongly curved, occasionally bidentate.

Involueral bracts very large, ovate, deeply cordate, the auricles slightly curved inward, but not overlapping; the short inner margins united, usually for only 1 or 2 mm., sometimes for 4 or 5 mm.; teeth 13 to 19, very long and slender, attaining 3.5 cm. on bracts with total length of 8 cm.; three middle teeth not prominent, margins of auricles entire; bractlets of common occurrence; outer nectaries prominent, subrotund; inner nectaries subtriangular; pedicels rather short, attaining 3.5 cm., triangular, with deep grooves running down the angles, making six nearly equal grooves and ridges; calyx short, with five very shallow sinuate lobes.

Flowers very large, not opened beyond a cylinder, 9 to 9.5 cm. from the outer nectary to end of corolla; petals pale yellow, with small petal spots.

Bolls oblong-oval, abruptly acuminate, 3-locked or often only 2-locked, the surface somewhat lighter green, smoother and more even, and with smaller and more scattered punctations than in related species; mature open bolls not present.

Type in U. S. National Herbarium nos. 1,282,039, 1,282,040, and 1,282,041,

collected from a single plant at Bahia de Caraquez, Ecuador, May 12, 1926, by O. F. Cook and J. W. Hubbard (no. 112).

The plant grew among ivory-nut shells, and was so healthy and vigorous that a full development of vegetative branches would be expected, as well as full numbers of leaf-lobes, nectaries, and carpels, so that the peculiarities in such characters appear significant. The vegetative branches, though numerous, did not behave like the erect or strongly ascending, stiff woody shoots of the "tree" cottons, but showed a modified fruiting habit, soon spreading into horizontal or decumbent positions, with flowers and bolls near the ground, like a cultivated "annual" or "herbaceous" type of cotton. There were 18 vegetative branches, the lower about 1.5 meters long, the upper 1 meter, also vegetative shoots on some of the lower fruiting branches, from the basal or second joints. On a fruiting branch 85 cm. long, eight successive joints measured in centimeters as follows: 22, 10, 10, 9, 9, 10, 10, 3. The main stalk internodes and those of the vegetative branches were 4 to 5 cm. long.

The outstanding features are the spreading low-fruiting habit, the absence of 3-lobed leaves, the slight development of nectaries, both on the leaves and the involucre, the narrow oblong bolls, often with only 2 locks; and the very large involucral bracts greatly exceeding the bolls, with the teeth very numerous and long, and with the auricles deep and broad. Considered as a member of the South American series, the characters presented by this plant may afford an indication of the relationship of the Sea Island type of cotton.

Since only one plant of this type was seen, it may have been a hybrid, but it presents such an interesting series of characters that a description seems warranted. The large leaves and bracts, and the narrow, few-locked bolls, are not inconsistent with hybridism, but the rather spreading habit and the specialized character of the vegetative branches, short-jointed, and producing numerous fruiting branches near the ground, do not suggest a hybrid.

Gossypium evertum sp. nov.

Plants large and spreading, attaining a height of 10 or 12 feet, with stalks 3 or 4 inches in diameter at base; foliage dense, light green, glabrous; fruiting branches many-jointed, the basal joint usually long, from 12 to 18 cm., other joints from 2 to 5 cm.

Leaves a rather light, fresh-green, glabrescent, very young leaves sparingly covered with short stellate hairs below; lobes 3 to 5, usually 5, rather long, with long-acuminate points; sidelobes usually at right angles to the midlobes; auricles short, sinus open, basal curves or margins of the auricles often distinctly undulate; veins pale, prominent below; surface often bullate between veins near base; length of large 5-lobed leaf, on the midvein 18.5 cm., on the greatest expansion of the auricle 21 cm., width on points of forelobes 28 cm., width on points of sidelobes 20 cm.; leaf nectaries small, usually 3 on leaves of the main stalk and vegetative branches, but only one on leaves of fruiting branches; nectaries of the midveins rather large and deep,

with prominent rims, located about 1.5 cm. from base; nectaries of foreveins very small, 3 to 5 mm. from base, usually ovate or oval, sometimes reduced to a small narrow groove; stipules large, linear, fugacious, usually shorter and broader on the fruiting branches, often very irregular and unequal, one of a pair sometimes twice as large as the other.

Involucre light green, glabrous; bracts oval or ovate, subcordate, strongly concave or everted, exposing much of the inner surface, which is pale green and glossy; teeth 9 to 13, irregularly arranged, the 3 middle teeth not prominent; auricles very short, with entire margins, the inner margins regularly united; no trace of bractlets found; outer nectaries rather large, rounded or transversely oval, prominent above the surrounding surface, especially before flowering; inner nectaries rather large subtriangular; pedicels short, distinctly triangular, with a small groove running down each ridge; calyx, truncate or with only slight indications of lobing.

Flowers large, cylindrical, not opening widely; petals broad and widely overlapping, with a distinct lateral lobe or tooth at the point of the section exposed in the bud, pale yellow with small red petal spots and numerous golden yellow oil-glands, the venation very distinct; staminal column 2.5 cm. long, with small scattering yellow oil-glands; stamens not numerous, filaments rather short, in five distinct rows; anthers pale, medium size, pollen deep yellow; style long, stigma exerted about 1 cm.; oil-glands of styles in two widely spaced rows, the glands in one row alternating with those in the other.

Bolls 3-locked, about 5 cm. long by 2 cm. wide, narrowly conic-oval, acuminate, oil-glands large and scattering, surface slightly rugose, shining; ripe bolls open widely, the points curving backward, forming sharp hooks; seeds per lock 7.

Seed small, dark brown, naked at the base or nearly so, with a narrow band of short brownish fuzz near the middle, and sometimes small tufts of fuzz at either end; lint faintly tinged with buff, about $1\frac{1}{2}$ inches in length, slightly harsh; the lint is confined to the upper portion of the seed, from the band of fuzz to the tip.

Type in U. S. National Herbarium nos. 1,282,028 and 1,282,029, collected at Buenaventura, Colombia, April 30, 1926, by O. F. Cook and J. W. Hubbard (no. 63).

The distinctive characters are the light, fresh-green glabrous foliage, the strongly everted involucre, the lateral petal tooth and the distribution of fuzz and lint on the seed. The lower part of seed usually is entirely naked, the fuzz mostly restricted to a belt around the seed, where the lint begins.

The open involucre, with strongly everted bracts, may be considered as an adaptation to a humid tropical climate. Closed involucre appear disadvantageous, especially under humid conditions, because of the protection afforded to insect pests and plant diseases. Diseases like anthracnose and bacterial boll-rot are very common and destructive in tropical America.

Gossypium calycotum sp. nov.

Plants large, spreading, 8 to 10 feet high, the large fruiting branches with long basal joints like Egyptian cotton, though the foliage appears more like Upland cotton.

Leaves light green, simple or 3 to 5 lobed, the upper surface subglabrous, the lower surface rather densely covered with very short stellate or tufted

hairs; lobes rather short, subtriangular, acuminate, sidelobes often represented only by a tooth; sinus between lobes rounded and open, the surface of the leaf usually flat; sidelobes often extending backward at an angle of about 50 or 60 degrees to the midvein and closing the basal sinus, though the auricles are rather short; length of blade on midvein 19 cm., on greatest expansion of auricle 24 cm., width on points of forelobes 30 cm., on points of sidelobes 20.5 cm.; veins prominent below, nectaries usually 3, appearing as long narrow slits, those on midvein located about 2 cm. from base, and attaining about 5 mm. in length, about twice as large as those on foreveins; petioles papillate, especially near base of leaf; stipules rather large, fugacious, very broad and strongly curved on fruiting branches, often broader than long, sometimes toothed.

Involucral bracts large, with 10 to 13 rather large teeth; at base cordate with an abrupt, deep sinus formed by the straight united inner margins of the auricles extending back along the pedicel for 8 to 10 mm.; lower margins open and slightly flared, forming nearly a right angle with the inner margins, lateral margins entire, often to the middle of the bracts, calyx rather short, subtruncate, with very slight indications of lobing; pedicels short, stout, triangular, 2 to 2.5 cm. long; outer nectaries subrotund, rather large, prominent, inner nectaries subtriangular or trapezoidal, usually slightly longer than broad; large auriform crests subtending and connecting the inner nectaries, the crests appearing occasionally like bractlets, but usually as ruffle-like appendages irregularly curled or rolled outward, extending around the base of the calyx, the bractlet-like crests apparently of the same texture as the calyx, with numerous small black oil-glands, but the more continuous crests with lower surface very pale and usually without oil-glands. Flowers not seen.

Bolls of medium size, attaining 5 cm. long, rather broadly conic-ovoid, with stout acuminate points, the surface rather closely and irregularly pitted; locks 3, with 9 or 10 seeds per lock.

Seeds dark brown, with a small tuft of light brown fuzz at base. Lint white, about 1½ inches long.

Type in U. S. National Herbarium nos. 1,282,033, 1,282,034, and 1,282,035, collected from a single plant at Esmeraldas, Ecuador, May 11, 1926, by O. F. Cook and J. W. Hubbard (no 105).

The remarkable broad auriform crests extending around the base of the calyx between the inner nectaries are the outstanding feature of this species. The crests are not parallel to the insertions of the bracts, but rise rapidly, usually to about half the height of the calyx, and sometimes to the full height, forming a semicircle between two of the inner nectaries. In many cases the crests are interrupted and occur as small separate sections between the nectaries, but always on a curve, like a complete crest. Below the complete crests the surface of the calyx is pale and without oil-glands.

Gossypium auritum sp. nov

A large spreading perennial shrub, attaining 8 to 10 feet in height and 3 to 4 inches in diameter at base, the large fruiting branches with long basal joints, often attaining 18 to 20 cm.; foliage deep green, subglabrous.

Leaves large, usually with 5 lobes, even on rather small leaves; midlobes large, ovate, oblong, abruptly acuminate, often apiculate; the forelobes large sometimes nearly equal to the midlobes; the sidelobes usually short,

broadly triangular, auricles ample, often overlapping, texture rather heavy, upper surface glabrous, strongly upfolded between the bases of the primary veins, callus and veins whitish, lower surface pale green, with few stellate hairs, length of large leaf on midvein 19 cm, on the greatest expansion of the auricle 24 cm., width on points of forelobes 30 cm., width on points of sidelobes 23 cm., leaf nectaries short, broadly ovate or cordate, sometimes 3, usually only one even on large 5-lobed leaves, inserted low on the midvein, often 1 cm or less from the base, nectaries of foreveins sometimes only 3 to 4 mm from the base, petioles long, stout, attaining 21 cm in length, with a distinct pulvinus at each end, the upper pulvinus papillate, stipules large, fugacious linear on vegetative branches, much broader on fruiting branches, sometimes nearly as broad as long, and strongly curved, occasionally bidentate

Involucral bracts large, subrotund, broadly ovate, the auricles unusually large and broad, united only slightly at base, the inner margin strongly curved, meeting or overlapping across the pedicel, thus forming a complete circle around the outer nectary, teeth rather small, usually 17, sometimes 19 or 20, the margins of the auricles entire, bractlets often present, outer nectaries very large, prominent, cuneate, inner nectaries large, triangular, with a border of black oil-glands, calyx with five distinct, very short, rounded lobes

Flowers large, 7 to 8 cm long, the petals pale yellow, with small petal spots, staminal column rather long, about 2.8 cm, naked section at base about 8 mm, stamens numerous, filaments short, anthers small, light brownish, stigma exserted about 5 mm above stamens, the apex divided for about 3 mm into 3 distinct lobes

Bolls large, attaining 6.5 cm by 3 cm, ovate-oblong, abruptly acuminate, usually 3-locked, sometimes 4-locked, with 12 or 13 seeds per lock, fissures deeply grooved near the tip, surface rather dark green, shining, rather coarsely and deeply punctate, with the oil glands distinct

Seed small, brown, gradually narrowed to a sharp beak, with a long spur on the funicle, the raphe often quite prominent, irregularly covered with short brownish fuzz, usually longer and more dense towards each end, with irregular patches near center, in places almost naked, lint white, very fine, silky, about 1½ inches long, but rather sparse and uneven

Type in U S National Herbarium nos 1,282,036, 1,282,037, and 1,282,038, collected from a single plant at Esmeraldas, Ecuador, May 11, 1926, by O F Cook and J W Hubbard (no 108). Specimens and photographs were also secured from a large plant in a door yard at Bahia de Caraquez, Ecuador

The outstanding characters of the species are the deep broad auricles and numerous teeth of the involucral bracts and the large 3-locked bolls containing 12 or 13 seeds per lock. The inner margins of the bract auricles often overlap across the pedicel, thus forming complete circles around the outer nectaries

Several characters of this species suggest the Ica cotton described by Spruce from northern Peru, particularly the large bolls and the large numbers of seeds in each lock, but the bracts of the Ica cotton are described as "lacinate all round the margin," and the outer nectaries as "obsolete"

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL 16

DECEMBER 18, 1926

No 21

HYDROLOGY and BOTANY—*Plants as indicators of ground water*¹ OSCAR EDWARD MEINZER, United States Geological Survey

PHREATOPHYTES

Perhaps the most outstanding feature of the flora of the desert is its relation or lack of relation to the water table. On the one hand are the true xerophytes, which have adaptations for extreme economy of water, depend on the rains that occur at long intervals for their scanty supplies of water, and during prolonged periods of drought maintain themselves in a nearly dormant condition. On the other hand are the plants that habitually grow where they can send their roots down to the water table or to the capillary fringe immediately overlying the water table and are thus able to obtain a perennial and secure supply of water.

The term phreatophyte is used by the writer to designate a plant that habitually obtains its water supply from the zone of saturation, either directly or through the capillary fringe.² The term is obtained from two Greek roots and means a "well-plant." Such a plant is literally a natural well with pumping equipment, lifting water from the zone of saturation. The term ground water is used in this paper to designate the water in the zone of saturation—that is, below the water table.

¹ Published by permission of the Director of the U. S. Geological Survey. Received Oct. 29, 1926.

² MEINZER, O. E., *Outline of ground-water hydrology, with definitions*, U. S. Geol. Survey Water-Supply Paper 484, 55, 1923. In so far as the writer is informed, the term phreatophyte was first used by him in a mimeographed edition of the paper which was later issued, in revised form, as Water-Supply Paper 484.

The phreatophytes form a fairly definite and well recognized ecologic group in the desert regions but a much less definite group in the humid regions where water supplies from other sources are more abundant. In the most arid deserts they stand in sharp contrast to the true xerophytes, which do not utilize water from the zone of saturation. As one passes, however, into less arid and then into more and more humid regions the control of the water table becomes progressively less rigid, until its discipline, as it were, becomes quite demoralized, and even its most subservient vassals wander away and live at will in all sorts of situations where they are entirely beyond its control.

Even in the desert regions many if not all phreatophytic species will spread more or less to localities where they are not in reach of the water table, such as irrigation ditches, irrigated fields, streams and dry washes that are far above the water table, or even alluvial slopes and hillsides. It is also true that plants of species which do not habitually utilize ground water may do so under certain circumstances and may flourish, at least for a time, on such a water supply. Moreover, there is not always a wholly definite distinction between ground water and other soil moisture because of the existence of a great variety of perched and temporary water tables and of gravity water that may be in transit from the surface to the water table. However, these exceptions and complicating conditions do not alter the important fact that there are certain plant species which habitually feed on ground water and others which do not, and that in the arid regions there is a very real and conspicuous distinction between these two groups.

HISTORY OF THE SUBJECT

As might be surmised, the subject of plants as indicators of ground water is by no means a new one. Vitruvius, who lived about the time of Christ and who is credited as being the first writer to advocate the modern theory of the origin of ground water, called attention to the value of certain plants in locating water supplies. Statements on the same subject are found in the writings of Pliny, in the first century A. D., who virtually quoted Vitruvius, and in those of Cassiodorus, in the sixth century, who obtained his ideas largely from a professional water finder that came to Rome from the arid regions of Africa.

The subject has, however, received little attention in modern times in the European countries in which the science of ground-water hydrology has been developed. Most of the French and German

treatises on ground water either do not mention it at all or else dispose of it very briefly. The reason for this is doubtless that the hydrologic work in these countries was done chiefly where relatively humid conditions prevail and where, therefore, the subject of plants as indicators of ground water does not have much significance. It may be noted that Cassiodorus became interested in the subject through an "aqui-lege" who came to the court of Theodoric from Africa. "Because of the great aridity of the terranes of his country," wrote Cassiodorus, "the art of discovering springs is there cultivated with the greatest care." The most definite and thorough study of the subject seems to have been made by a Frenchman named Amy,³ who published a comprehensive paper on his observations in 1861. The proposition that plants of certain species more than others utilize water from the zone of saturation has been recognized by various eminent botanists, such as Warming, who based his statements largely on the work of Fielberg, Raunkiar, and Massart.

In the desert region of the United States, which covers about half a million square miles, the relation of the native vegetation to ground water is a subject of great scientific and practical importance, yet even in this region it has received but little systematic study. Coville,⁴ in a report on a botanical reconnaissance in the Mohave Desert and Death Valley in 1891, described the zonal arrangement of the vegetation surrounding playas and divided the plants found in the desert into two significant classes—those of humid habitat and those of arid habitat. His list of plants of humid habitat probably comes nearer to being a catalogue of desert phreatophytes than anything else that has been published in this country. The botanists of the Desert Botanical Laboratory, which was established in 1903, have generally recognized the relation of certain species to the water table, and the subject has been given especial attention by Spalding⁵ and Cannon.⁶ In a valuable investigation made by the Department of Agriculture

³ AMY, F., *Voyages d'un hydroscopie, ou l'art de decouvrir les sources*. Paris. 1861

⁴ COVILLE, F. V., *Botany of the Death Valley expedition*. Contrib. U. S. Nat. Herb. 4: 23, 31, 32, 35, 38, 39, 47. 1893.

⁵ SPALDING, V. M., *Distribution and movements of desert plants*, Carnegie Institution of Washington Pub. 113: 5-17. 1909

⁶ CANNON, W. A. *The root habits of desert plants*, Carnegie Inst. Washington Pub. 131. 1911 *Some relations between root characters, ground water, and species distribution*, Science new ser. 37: 420-423. 1923. *Tree distribution in central California*, Popular Science Monthly pp 417-424, 1914

of the indicator significance of native plants in Tooele Valley, Utah,¹ the relation of the principal phreatophytes, such as greasewood, to the water table was recognized and some precise information was obtained bearing on the subject of plants as indicators of ground water. Valuable work has more recently been done by Shantz, Aldous, Piemeisel, and others on the general subject of the indicator significance of native plants in the arid and semiarid regions of the United States, including some reference to ground water. Much of this recent work has been done in connection with the classification of the public domain by the Geological Survey with respect to its irrigability and its value for grazing. In the older water-supply papers of the Geological Survey dealing with ground water no mention is generally made of discharge by plants or indeed by evaporation from the soil. In recent years, however, in the investigations in the desert regions the great importance of these processes has been fully recognized and attention has necessarily been given to the plants that feed on ground water. The numerous water-supply papers that have resulted from these investigations contain considerable specific information on the subject, especially those of J. S. Brown, Kirk Bryan, Everett Carpenter, W. O. Clark, C. H. Lee, C. W. Riddell, C. P. Ross, A. T. Schwennessen, D. G. Thompson, and G. A. Waring. Decisive data on certain species have been obtained through the use of water-stage recorders over wells by G. E. P. Smith, irrigation engineer in the University of Arizona, and by W. N. White, of the United States Geological Survey. The present paper is based chiefly on observations made by the writer during 19 years of hydrologic work in the desert region, but also in large part on the data published in papers by the investigators that have been mentioned.

EVIDENCES OF PHREATOPHYTIC HABIT²

The evidences that plants of certain species possess the phreatophytic habit or adaptation whereas those of other species do not may be grouped as follows: (1) Observations of the root habit of different species showing their relation or absence of relation to the water table

¹ KEARNEY, T. H., BRIGGS, L. J., SHANTZ, H. L., McLANE, J. W., and PIEMEISEL, R. L., *Indicator significance of vegetation in Tooele Valley, Utah*. U. S. Dept. Agric. Journ. Agric. Research 1: 365-417. 1914.

² Detailed data on the subject are given in a comprehensive paper by the writer which has been approved by the Director of the United States Geological Survey for publication as a water-supply paper.

and showing the ability of some species to send roots to great depths, (2) experiments with certain species in which the quantities of water they absorb from the zone of saturation are measured or the effects of their growth in lowering the water table are recorded, (3) determinations of soil moisture during dry periods in an arid region, showing that certain species grow chiefly or exclusively in soil which contains moisture that could not have been supplied by rains but must have risen from the zone of saturation, whereas other species are found chiefly or exclusively with their roots in soil that is not moistened by ground water, (4) observations in arid regions of the relation or absence of relation of the period of growth of different species to the rainy season, showing that certain species (commonly growing where the ground water is beyond the reach of the plant roots) become dormant after the supply of soil moisture derived from the rains has been exhausted, whereas other species (growing where the ground water is within reach) continue to grow actively throughout the summer, and (5) observations in arid regions of the depth to the water table, showing that certain species are confined almost completely to areas with specific depth limits, whereas others show no relation to the water table and may grow where the water table is at a great depth or is entirely absent. The zone of shallow ground water surrounding a desert playa can generally be subdivided into several concentric belts of vegetation, in each of which one or more phreatophyte species is dominant. The successive belts vary in texture and alkalinity of soil as well as in depth to the water table. However, the main factor in the control of the vegetation over the area of shallow ground water is the depth to the water table. This fact is proved by the existence of otherwise similar basins which, on account of subterranean leakage, do not have shallow ground water in their interior lowlands. In these basins there may be a barren central playa with clayey, alkaline soil, surrounded by belts of soil having essentially the same texture as that of the soil in the basins that have shallow ground water, yet the familiar phreatophytes are essentially absent and the ordinary desert species extend to the margins of the playas. Doubtless there are some differences in the amount and distribution of the alkali in the soil resulting from the absence of shallow ground water, but in view of the characteristic growth of phreatophytes in many well-drained areas of shallow ground water it is certain that the absence of these species in the basins having deep ground water is not due to a difference in soil alkali.

RELATION OF PHREATOPHYTES TO OTHER ECOLOGIC GROUPS

Relation to hydrophytes—Water-loving plants might be divided into (1) those which grow entirely under water, (2) those which have only their roots under water, (3) those which have their roots in saturated soil, and (4) those which grow where there is a zone of aerated soil between the land surface and the water table but where the zone of saturation or the overlying capillary fringe is within reach of their roots. The phreatophytes consist of the last two of these groups. If the term hydrophyte were used in a very inclusive sense to comprise all four groups then the phreatophytes would, of course, become a subdivision of the hydrophytes.

However the distinction as to whether the body of water that feeds the plant is surface water or ground water is perhaps less important than the relation of the roots to the body of water—a question on which there is still great lack of information. Many phreatophytes probably develop a root system in the capillary fringe and avoid, so far as possible, sending their roots into the zone of saturation, thus differing in an important respect from true hydrophytes, whose roots are normally under water. However, the phreatophytes which are closely allied to the hydrophytes and which grow where the water table is very near the surface doubtless have functional roots in the zone of saturation. Moreover, G. E. P. Smith found both cottonwood and mesquite roots highly developed below the water table. The water table everywhere fluctuates. In most places within the areas occupied by phreatophytes the seasonal fluctuation amounts to as much as 2 or 3 feet and in some places it amounts to more than 25 feet. This fluctuation is probably beneficial because on the whole it produces a thicker belt of aerated soil that is moistened by ground water. It, however, raises interesting and important questions as to how the root system is adjusted to the fluctuations of the water table.

Relations to halophytes—The halophytes in the arid regions virtually form a subdivision of the phreatophytes because the alkaline soils in which they grow are nearly confined to the areas that have ground-water discharge. Nevertheless many of these halophytes resemble the xerophytes in having to subsist on small quantities of water. It is well known that a plant in order to absorb soil water must have a tissue fluid of higher osmotic pressure and, therefore, of higher salt content than the soil water. For this reason the highly concentrated soil water is relatively unavailable to the plants, and the soil that

contains such highly concentrated water is said to be physiologically dry even if it is saturated. Because of the slow rate at which these halophytes absorb water they require adaptations for controlling transpiration similar to those of xerophytic plants. The high concentration of the tissue fluid itself retards transpiration.

The soils and subsoils underlying many of the playas and adjacent belts of succulent halophytes are, moreover, very clayey and tight, and therefore have only small supplies of available water in spite of the high water table and abundant water supply of the surrounding belt of more permeable soil. Thus the supply available to plants may be meager because of the fine texture and impermeability of the soil and subsoil as well as the high concentration of the soil water. It is known, however, that in the more permeable belts surrounding the clay cores a very alkaline soil may be underlain by ground water that is not excessively mineralized and that may indeed be very pure. Grasses that flourish on alkaline soil, such as salt grass and alkali sacaton apparently have considerable transpiration. This fact leads to the suggestion that they may obtain most of their water supply not from the physiologically dry soil but from the relatively pure water of the zone of saturation. Deep rooting plants that are found in alkaline soils may also be relatively independent of the alkali in the top soil and may feed on the relatively pure ground water.

Relation to xerophytes.—The desert phreatophytes have a humid environment for their roots but they resemble the xerophytes in having a dry environment for their transpiratory organs. Moreover, some phreatophytes, chiefly those which send their roots to great depths to reach the water table, have considerable ability to endure adverse soil-moisture conditions when they are not in contact with an adequate ground-water supply. The young plants of these species, if they have grown from seeds, must be able to withstand drought until their roots reach the ground water; moreover, if they find ground water only at great depth the rate at which they can lift the water to their stems and leaves may be too low to allow rapid transpiration. However, the reward of a perennial water supply comes to the individual plants that are not only thrifty in their use of soil moisture, but are also effective in sending down their roots. The individuals that reach the water table are likely to survive and to reproduce their kind in preference to those that were less successful in developing deep roots. Moreover, among the individuals that reach the water table the victory will, as a rule, be to those which are the most capable in utilizing

ground water. Hence, natural selection should produce a species which has xerophytic adaptations but which nevertheless is an efficient phreatophyte with a capacity to send strong roots to great depths rapidly and to pump ground water effectively up through these roots.

Relations to mesophytes.—A number of species, chiefly forest trees such as birch and sycamore, are widely distributed through the humid regions and also grow in arid regions where ground water is within reach. They are generally regarded as mesophytes rather than hydrophytes. They are mesophytes in the sense that they can not tolerate much alkali and apparently have no special adaptations for resisting drought. In the arid regions they are found in the mountain canyons and large arroyos that have an underflow and in other places that have shallow ground water but fairly good drainage. They are commonly not associated with salt grass and greasewood, on the alkaline soils, nor with mesquite in areas of good soil where the water table is at considerable depth. Even casual observations of the forests in humid regions will show that the trees of this type have an affinity for the water table in humid as well as in arid regions. If it were not for their ability to utilize water from the zone of saturation and the poor development of this adaptation in other trees it could reasonably be expected that the other trees would be the most successful and the water-loving trees the least successful in establishing themselves in the arid regions.

VALUE OF PHREATOPHYTES AS INDICATORS OF GROUND-WATER CONDITIONS

Occurrence of ground water.—The phreatophytes are of great practical value as indicators of the occurrence of ground water in arid regions. They give evidence which supplements that furnished by the topography and geology and is more specific as to the precise localities where the water occurs near the surface. They can not properly be ignored or relegated to casual consideration in any ground-water survey of a desert region. Many inhabitants of desert regions have a keen appreciation of the value of plants as indicators of ground water and an almost intuitive sense of the significance of particular native species. Doubtless some of this practical knowledge was possessed by primitive men long before the dawn of human history, and indeed as long ago as man first essayed to dwell in the desert regions or to cross the vast expanses of these dread regions.

These plants are also of great value to travelers in the desert in directing them to existing watering places. In an uninhabited region in which the distance between watering places may be 10, 20 or 50 miles it is sometimes difficult for a stranger to locate the precise spot where the water occurs even with such clues as are furnished by roads and animal trails. Clumps of cottonwoods or of tall stately palm trees may be visible from a great distance and much help and comfort may also be afforded by so humble a phreatophyte as salt grass either by being visible as a green patch at a distance or at closer range by giving the traveler definite assurance of the proximity of ground water and virtual assurance that the watering place is not far away.

Depth to the water table—The clues as to depth to ground water that can be obtained from the different plant species are of considerable practical value and for persons in distress they may be a matter of life or death. Thus a person without tools and in a weakened condition might be unable to dig down to the water that supplies a mesquite bush although he would have a good chance of finding water where salt grass and palm trees are growing. In estimating for a given area the acreage of irrigable land within certain feasible limits of lift invaluable use can be made of the clues furnished by the successive belts of native vegetation. The limits of depth for all species are somewhat indefinite and are affected by the texture of the soil. With a few exceptions the greatest depth below the surface from which ground water is known to be lifted by plants is about 50 feet.

GENERAL LIMITS OF DEPTH TO WATER TABLE INDICATED BY PRINCIPAL
PHREATOPHYTES IN AREAS INVESTIGATED

Rushes and sedges—Water at surface or water table within a few feet

Giant reed grass (*Phragmites communis*)—Water at surface or water table within a few feet—probably not more than 8 feet. Giant wild rye (*Elymus condensatus*)—Water very near surface to a depth of 12 feet or more. In subhumid regions wild rye may grow without relation to water table.

Salt grass (*Distichlis spicata*)—Water very near surface to a maximum depth of 8 to 12 feet or rarely more.

Mexican salt grass (*Eragrostis obtusiflora*)—Water very near surface to depth of about 15 feet.

Pickleweed (*Allenrolfea occidentalis*)—Water generally within a few feet but sometimes at a depth of 20 feet and more.

Arrow weed (*Pluchea sericea*).—Water at surface or water table at depths ranging to 10 feet or more—probably as much as 25 feet.

Palm trees (*Washingtonia filifera*).—Water table within a few feet.

Willow.—Water at surface or water table 12 feet or more below surface (?).

Alkali saccaton (*Sporobolus airoides*).—Water less than 5 feet to depth of 25 feet and in some places much more. Most luxuriant growth where depth is between 5 and 15 feet. Alkali saccaton that occurs where depth is much more than 25 feet probably does not send roots to ground water.

Rabbit brush (*Chrysothamnus graveolens*).—Water about 2 to 15 feet below surface, 8 feet or more for most luxuriant growth. Also grows extensively as a non-phreatophyte.

Big greasewood (*Sarcobatus vermiculatus*).—Water 3 feet or less probably to depth of 40 feet or more. Abundant and luxuriant growth between 10 feet (or less) and 20 feet. Greasewood that occurs where depth is more than 50 feet probably does not send roots to ground water.

Mesquite.—Water less than 10 feet to 50 feet or more below surface. Mesquite that grows where depth is much more than 50 feet probably does not send roots to ground water.

Quality of ground water.—That certain plants indicate the quality as well as the occurrence of ground water is widely believed by people in arid regions, and there is doubtless some basis for this belief. In general the rushes, sedges, and reeds indicate fairly good water, but there are probably many exceptions to this rule. The succulent alkali-resistant plants, such as pickleweed and samphire, are likely to indicate highly mineralized water immediately under the water table, but the water a little deeper down may be much better. Where salt grass or alkali saccaton is growing the water may be good or it may be very bad. Palm trees and greasewood also indicate water of doubtful quality, but potable water can generally be obtained in the vicinity of vigorous palms. Mesquite generally though not invariably indicates good water. The meso-phreatophytes, such as birch and sycamore, commonly indicate good water.

The data obtained by the writer show that the species which he investigated, with the possible exception of pickleweed (*Allenrolfea occidentalis*), may grow where the upper layer of ground water contains only small amounts of mineral matter and is of good quality. Thus, of 13 samples of ground water obtained in Big Smoky and Ralston

Valleys, Nevada, at points where salt grass was growing, 11 samples contained less than 1,000 parts per million of total solids, 8 contained less than 500 parts, and 5 contained less than 300 parts, the minimum being only 137 parts. Of these 13 samples more than half contained less than 35 parts per million of chloride, the minimum being only 4 parts. Greasewood and rabbit brush, in Big Smoky Valley, and alkali saccaton and mesquite in Sulphur Spring Valley, Arizona, have equally good records.

On the other hand, the data show that all these species may be found growing where the ground water is highly mineralized, even mesquite not being an exception. This is not surprising when one considers the usual high concentration of soil moisture in comparison to that of ground water. Even though the plants may to some extent avoid the soil alkali by getting their roots close to the water table they can not wholly avoid it, especially at times when a part of the alkali is washed down to the water table. For this reason it is perhaps futile to expect that any definite relations can be found between the occurrence of phreatophytes and the quality of the ground water or that any species that can grow in even moderately alkaline soil will invariably indicate potable water.

Quantity of ground water.—In many of the arid valleys of the West projects for pumping large quantities of water from wells for irrigation or public supplies have been carried out or are under consideration. For these projects it is necessary to know as nearly as possible how much ground water can be recovered year after year without seriously depleting the supply stored in the underground reservoirs. As a rule the pumpage should not exceed the natural discharge but should merely salvage the ground water that would otherwise be disposed of by natural processes. In these valleys the ground water is naturally discharged largely by transpiration. To estimate the quantity annually discharged from a given valley it is necessary to determine both the areas occupied by these plants and the rate at which they give off water by transpiration.

The areas occupied in a given valley by the different associations of phreatophytes can readily be determined by a survey of the valley. The information thus obtained, even without any definite information as to the rate of transpiration, is of great practical value in estimating the probable safe yield of the valley and in determining the magnitude of pumping projects to be undertaken. For example, in Steptoe Valley, Nevada, in which exploratory drilling was done several years ago by

the Geological Survey,* it was found that ground water is being discharged, through evaporation from soil and the growth of native plants such as salt grass, rabbit brush, and greasewood, over an area of about 115,000 acres. The discharge per acre is probably much less than the quantity of water required per acre to irrigate useful crops, such as alfalfa, grain, or vegetables, and, moreover, not all of this water can be salvaged by pumping from wells. Nevertheless, the great extent of the area of discharge and the luxuriant character of its vegetation give reliable evidence that a substantial supply of ground water is available.

The rate at which ground water is discharged by plants may reasonably be expected to vary with the plant species, the depth to the water table, the texture and alkali content of the soil, and the weather conditions. Each of these factors is somewhat complex, especially the last two. Various ingenious methods have been devised for determining the rate of ground-water discharge by transpiration, and some of these methods are now in use by the Geological Survey.

DEVELOPMENT OF PHREATOPHYTES OF ECONOMIC VALUE

The extensive investigations of the Geological Survey have shown that very large supplies of ground water occur in practically all the western States. In California about a million acres are irrigated with ground water pumped from wells, but in the other arid States comparatively little irrigation has hitherto been accomplished with water from wells because of the prohibitive cost of pumping, and, therefore, most of the annual supply of ground water goes to waste or supports plants of very low value. The investigations in Big Smoky and Steptoe Valleys, Nevada, indicate that not far from 10 per cent of the drainage basins of these valleys contain plants that live on ground water. If these basins have anywhere near average conditions it follows that there are a few million acres of phreatophytes in Nevada alone. A part of this land is alkaline but much of it has good soil. Pumping water for irrigation is expensive even where the lift is not great. The plants, however, lift the water without cost, and if phreatophytes of economic value can be developed the means will be at hand for utilizing vast quantities of water that now virtually go to waste and making hundreds of thousands of acres of desert land productive. The best results in this type of agriculture have thus far been obtained with alfalfa, chiefly for producing seed. Bermuda grass and pecan trees are also examples of promising phreatophytes of economic value.

* CLARK, W. O., and RIDDELL, C. W., *Exploratory drilling for water and use of ground water for irrigation in Steptoe Valley, Nev.* U. S. Geol. Survey Water-Supply Paper 467: 13, 1920

BOTANY.—*New plants mainly from western South America*¹ ELLSWORTH P. KILLIP, U S National Museum

The representation of plants from western South America in the United States National Museum has increased substantially in recent years as a result of extensive collecting by local South American botanists and by members of scientific expeditions from the United States to South America. In the course of studying this material several new species have been discovered, descriptions of which are here published in order that the names may be available in the preparation of reports upon these collections. A single species from eastern Argentina is included.

Anthurium antrophyoides Killip, sp. nov.

Plant terrestrial, caudex 4 to 6 cm long, 1 to 2 cm thick, petioles 14 to 18 cm long, canaliculate above, geniculate at base, leaves rhombic-ovate-lanceolate, 17 to 18 cm long, 9 to 10 cm wide, with a triangular long-acuminate apex, abruptly cuneate-narrowed to petiole, suboblique, coriaceous, bright green, minutely and densely whitish-punctate above, glabrous, the nerves and veins prominent, the basal nerves 4 to a side, the outermost nerve reaching to within 0.3 mm. of the margin in the lower half, extending to base of acuminate apex and anastomosing with second basal nerve, the second nerve reaching to about 1.5 mm from the margin just above middle, and extending to apex, the 2 inner basal nerves and the lateral nerves (about 8 to a side) anastomosing with the second nerve above middle, peduncle about 12 cm long, spathe oval, 5 cm long, 3 cm wide, rounded at apex and abruptly caudate-acuminate (acumen 1 cm long), white, stipe 1 cm long, spadix 3 cm long, 0.5 cm. thick, perianth segments equal, about 0.8 mm long, 1 mm wide.

Type in the U S National Herbarium, no. 1,143,244, collected along Río Caballero, near junction with Río Dagua at Santa Rosa, Department El Valle, Colombia, altitude 200 meters, September 22, 1922, by E. P. Killip (no. 11555).

According to Engler's revision of *Anthurium* in Das Pflanzenreich this species apparently comes nearest *A. weberbaueri*, the venation and general shape of the leaves being quite similar. The leaves of *A. antrophyoides*, however, are acute at base, not obtuse, the spathe is proportionately much broader, the peduncles are shorter than the leaves while in *A. weberbaueri* they exceed the leaves, and the flowers are smaller. Comparison of the type specimen with type material of *A. weberbaueri* at Berlin has been made by the writer.

The leaves of *A. antrophyoides* bear a very close resemblance to the fronds of the tropical African fern *Antrophyum mannianum*.

¹ Published by permission of the Secretary of the Smithsonian Institution. Received October 11, 1925.

Anthericum herrerae Killip, sp nov

Plant about 30 cm high, glabrous except at leaf margins. Leaves basal, linear, 10 to 20 cm long, 0.8 to 1 cm wide, conduplicate, often ~~calcareous~~ ^{acute}, 25 to 30-nerved, densely ciliate, membranous, stem terete, naked or bearing a single bract-like leaf in upper third, the leaf linear-lanceolate, 2 to 4 cm long, 0.5 to 0.7 cm wide subconduplicate, raceme simple or few-branched, bracteate, the lower bracts lanceolate, up to 2.5 cm long, the upper ovate-deltoid, 0.5 to 1 cm long, pedicels ascending, about 5 mm long, articulate just above middle, perianth yellowish-white, the segments narrowly oblanceolate, about 1 cm long, 0.2 to 0.3 cm wide, obtuse, 3-nerved, filaments about 5 mm long, anthers linear, 3 mm long, ovary oblong, depressed at apex, the ovules 5 or 6 to a cell, style filiform about 6 mm long.

Type in the U S National Herbarium, no 1,281,329, collected at Hacienda Churú, Province of Paucartambo, Peru, altitude 3,500 meters, January, 1926, by F L Herrera (no 1012a).

This plant evidently is nearest *A sprengeli* Rusby (*A ciliatum* (H B K) Spreng, not *A ciliatum* L f) a species with oblong perianth segments and much longer filaments.

Brodiaea viridior Killip, sp nov

Bulb globose, about 1 cm in diameter, leaves 3 or 4, narrowly linear, 25 to 35 cm long 0.5 to 1.2 cm wide, subcarnose nearly flat, scape erect, 20 to 30 cm high, 1 or 2-flowered, spathe bivalved, the valves linear, 1.5 to 2.5 cm long, connate at base, about 10-nerved, white, pedicels 2 to 3 cm long, slender, subarticulate at apex, perianth tube cylindric 8 to 12 mm long, about 6 mm wide, the segments oblong-lanceolate, 15 to 20 mm long, 4 to 4.5 mm wide, widest at middle, tapering to a subcaudate apex, white, green along the single conspicuous nerve and in upper third, stamens in 2 series, borne at throat of tube, the filaments filiform, 3 to 5 mm long, style 9 to 10 mm long, ovary sessile.

Type in the U S National Herbarium, no 704305, collected in the vicinity of General Roca Río Negro valley, Argentina altitude 250 to 360 meters, September 28, 1914, by Walter Fischer (no 122).

In Baker's key² to this group of species *B viridior* would come nearest *Brodiaea* (Milla, of Baker) *poepigiana*, a Chilean plant with lilac flowers having shorter, merely acute segments.

Zephyranthes parvula Killip, sp nov

Bulb globose, 1 to 1.5 cm in diameter, the neck 1 to 2 cm long, leaves 2 to 4, narrowly linear, 2 to 3 cm long, 1 to 1.5 mm wide, scutish, peduncles about 1.5 cm long, spathe 1.5 to 3 cm long, closely enveloping the flower tube, bifid in upper quarter, ovary sessile, flower tube narrowly funnel-shaped, about 1 mm wide at base, 3 mm wide at throat, 1.5 to 2 cm long, whitish in lower half, deep pink in upper, the segments oblong, subequal to tube, 5 to 7 mm wide, rounded at apex but usually with a minute tip, deep pink at center, pale toward margin, purplish-veined, stamens inserted just

² Journ Linn Soc 11 383 1871

above middle of tube, the filaments 6 to 8 mm long, exerted about 4 mm beyond throat of tube but extending not beyond lower third of segments, the anthers linear, about 2.5 mm long, styles 2 to 2.5 cm long, the stigmas capitate; fruit broadly ovoid, 4 to 5 mm long, seeds about 2 mm long, black.

Type in the U S National Herbarium, no 1,233,250, collected near city of Cusco, Peru, altitude 3,500 meters, October, 1925, by F. L. Herrera (no 822). A specimen collected by Casimir Watkins in 1916 also belong to this species.

In Baker's revision³ of *Zephyranthes* this species would come nearest *Z. albicans* and *Z. boliviensis*, the only species of the subgenus *Pyrolirion* with light-colored flowers. It is a much smaller plant than either of these, and the stigmas are capitate, not trifid.

The local name is given as *pulla-pulla*.

Boerhaavia verbenacea Killip, sp. nov.

Plant herbaceous, annual, erect, up to 60 cm high or more, stems terete, somewhat viscous, glabrescent below, puberulous above, the branches stout, leaves lanceolate or narrowly oblong-lanceolate, 1.5 to 3 cm long, 0.4 to 1 cm wide, obtuse or acutish at apex, acute at base, subsessile (or the lower with petioles up to 1.5 cm long), entire or slightly undulate, viscid-puberulent, black-punctate, especially beneath, inflorescence paniculate, the panicle up to 30 cm., dichotomous, the branches glabrous, longitudinally striate with black, the flowers sessile or short (not more than 1 mm)-pediceled, in racemes 3 to 7 cm long, bracts ovate-lanceolate, 2 to 4 mm long, acute mucronate, pale at margin, persistent, perianth 1.5 to 2 mm long, puberulent, stamens 2, included, fruit broadly obovoid, 3 mm long, 2 to 2.5 mm wide, truncate at apex, 5-angled, the angles with conspicuous crenulate or subentire wings, the sulci rugose.

Type in the U S National Herbarium, no 1,291,334, collected at Talara, Department of Piura, Peru, near sea-level, August 22, 1925, by Oscar Haught (no 8).

This is apparently the only species of *Boerhaavia* with racemose flowers known from South America. From the seven Mexican species with a similar inflorescence *B. verbenacea* is readily distinguished by the fruit, which is nearly twice as wide and wing-angled.

Escallonia claudii Killip, sp. nov.

Shrub, essentially glabrous throughout, younger branches straight or slightly flexuous, quadrangular, sulcate, smooth, yellowish, densely leafy in upper part, leaves simple, obovate or ovate, 0.5 to 2.5 cm long, 0.4 to 1.5 cm wide, rounded or acute at apex, cuneate at base, finely callous-serrulate, penninerved (midnerve prominent beneath, the 5 or 6 pairs of lateral nerves less prominent), coriaceous, light green when dry, finely puberulous above, flowers solitary in the axils of the upper (floral) leaves on branches up to 8 cm long, forming a simple raceme, the pedicels 1 to 2 mm long, quadrangular,

³ Amaryll., p. 30. 1888.

bibracteate; bracts linear, 2 to 3 mm. long, coriaceous; calyx oblong, 2 to 3 mm. long, 1.5 to 2 mm. wide at throat, the lobes deltoid-subulate, about 0.5 mm. long; petals linear-spatulate, 6 to 8 mm. long, about 0.8 mm. wide below, dilated to about 3 mm. toward apex, white or pink (?), erect, the lobes divaricate, conspicuously purple-veined; stamens at length recurved, filaments slightly shorter than the petals, the anthers linear, 2 to 2.5 mm. long; style 6 to 8 mm. long, the stigma capitate; ovary turbinate, sulcate.

Type in the U. S. National Herbarium, no. 1,059,295, collected at Ramón, Chile, November 25, 1920, by Brother Claude Joseph (no. 1281).

In Reiche's Flora of Chile⁴ and in Engler's monograph⁵ of *Escallonia* this new species would come nearest *E. carmelita* Meyen. That species, however, has elongate calyx lobes which are nearly as long as the tube, shorter anthers, and nearly terete branches.

This is one of several plants of exceptional interest represented in the large Andean collections sent the U. S. National Museum by Brother Claude Joseph.

Weinmannia caucana Killip, sp. nov.

Tree; bark of younger branches dark silvery-gray, the ends of the branches and rachis of the racemes densely ferruginous-hirsute; leaves simple, oblong or ovate-oblong, 3.5 to 7 cm. long, 2 to 3 cm. wide, acute or rounded at apex, tapering at base to a petiole 2 to 8 mm. long, coarsely serrate, penninerved (lateral nerves up to 20 pairs), subcoriaceous, dark green and sparingly hirsutulous above, slightly paler and appressed-hirsute on the midrib beneath, the floral leaves similar and smaller; racemes in pairs, 6 to 10 cm. long, the flowers densely congested in contiguous clusters, the pedicels about 3 mm. long; sepals lanceolate, 1 mm. long or less, acute; petals broadly ovate, about 0.8 mm. long, rounded and emarginate at apex, white; stamens very slender, about 3 mm. long, the anthers minute.

Type in the U. S. National Herbarium, no. 1,143,824, collected at Morlos, Cauca Valley, Department of El Cauca, Colombia, altitude 1,680 to 1,720 meters, July 13, 1922, by F. W. Pennell and E. P. Killip (no. 8306).

Related to *W. ovata* Cav. and *W. balbisiana* H. B. K. It differs from the former in having thinner leaves with different venation, denser inflorescence, and smaller flowers; from the latter, in the longer racemes and much smaller sepals, and in the shape of the leaves.

Weinmannia rollottii Killip, sp. nov.

Shrub or small tree, the young branches ferruginous-strigose; leaves simple, ovate-oblong, 1.5 to 3 cm. long, 1 to 2 cm. wide, rounded at apex, rounded or slightly cordulate at base, short (about 4 mm.)-petioled, serrate-dentate, coriaceous, penninerved (about 8 pairs of lateral nerves), reticulate-veined, glabrous or sparingly hirtellous above, hirtellous, especially on the nerves, beneath, the floral leaves smaller, ovate-spatulate, acute at base, subentire; racemes in pairs, 5 to 8 cm. long, ferruginous-strigose, the flowers in approxi-

⁴ 3: 14-32. 1902

⁵ *Linnaea* 36: 532-579. 1870.

male clusters of 4 to 6, the pedicels about 2 mm. long; sepals lanceolate, 1 to 1.5 mm. long, acute, slightly carinate, minutely pilosulous toward apex; stamens 1 mm. long; capsule lance-ovoid, 3 to 3.5 mm. long, glabrous; styles filiform, 2 to 2.5 mm. long.

Type in the U. S. National Herbarium, no. 1,067,899, collected near Páramo de Guasca, Department of Cundinamarca, Colombia, December 27, 1919, by M. A. Rollott (Brother Ariste Joseph) no. A476.

This species is related to *W. bangii* Rusby, but has thicker, smaller leaves, shorter pedicels, and shorter racemes.

Weinmannia nervosa Killip, sp. nov.

Shrub (?); younger branches hirtellous-tomentose; stipules orbicular, 2 to 2.5 mm. wide; leaves 4 to 6 cm. long, short-petioled (petiole about 5 mm. long), unequally pinnate (lateral leaflets 2 to 4 pairs), the midnerve hirtellous-tomentose, leaflets crenate-serrate with 6 to 10 serrations to a side, reticulate-veined (veins prominent above as a grayish network, inconspicuous beneath), subcoriaceous, above dark green, glabrous except for the minutely hirtellous midnerves, beneath light brown (when dry) and glabrous; terminal leaflet obovate or elliptic-ovate, 1.5 to 2.5 cm. long, 1 to 1.2 cm. wide, slightly narrowing toward the obtusish apex, cuneate at base; lateral leaflets oblong, 1 to 2 cm. long, 0.7 to 1 cm. wide, rounded at apex, obliquely cuneate at base; intrafoliar leaves semi-obovate, 7 to 8 mm. long, 1.5 to 2 mm. wide; pseudo-racemes in pairs, 6 to 7 cm. long, the rachis short-hirtellous; bracts broadly ovate, barely 0.5 mm. long, obtuse; flowers 3 to 6 in a glomerule, the glomerules verticillate on the raceme; pedicels about 2 mm. long, longer than the flowers, minutely pubescent; sepals ovate, barely 0.5 mm. long, acute, sparsely pubescent or glabrate, petals ovate, 1 mm. long, obtuse; stamens about 1.5 mm. long, styles shorter than the stamens, as long as, or slightly longer than, the ovary; ovary glabrous.

Type in the U. S. National Herbarium, no. 533,715, collected in the Santa Marta Mountains, Colombia, altitude 1,400 meters, April, "1898-1901," by H. H. Smith (no. 1743).

This specimen was distributed as *W. sorbifolia* H. B. K., a species with leaves fully twice as large. In Engler's monograph of *Weinmannia*⁴ this species should come between *W. sorbifolia* and *W. lansbergiana*. From *W. glabra* L. f., another closely related species, it differs in the conspicuous venation on the upper surface of the leaflets and the longer pedicels of the flowers. The specimen was compared with the types of *W. sorbifolia* and *W. lansbergiana* at Berlin.

Geranium filipes Killip, sp. nov.

Rhizome vertical, 4 to 5 mm. thick; stems 2 or 3, all from the apex of the rhizome, slender, few-branched, erect or ascending, 10 to 15 cm. high, exceeding the basal leaves, densely subretorse-strigillose; stipules linear-lanceolate, 5 to 7 mm. long, about 2 mm. wide, acute, ciliate, otherwise glabrous; leaves orbicular-reniform in general outline, 1 to 1.5 cm. long, 1.5 to 2 cm. wide,

⁴ *Linnaea* 39: 592-650. 1870.

5-lobed about to middle (lobes trilobulate at apex, rarely entire, the segments rounded, mucronulate), membranous, appressed-strigillose above, appressed-pilous on nerves beneath, the basal and cauline leaves similar, petioles, the petioles 3.5 to 7 cm. long; peduncles solitary, very slender, 2 to 5 cm. long, retrorse-strigillose, 2-flowered; bracts linear, 3 to 5 mm. long, acuminate, glabrous; pedicels 4 to 6 cm. long, densely pilous; sepals lanceolate, 4 to 6 mm. long, 2 to 2.5 mm. wide, obtusish, conspicuously mucronulate, subternerved, appressed-hirsutulous, densely pilous on nerves; petals cuneate-obovate, 5 to 8 mm. long, about 3 mm. wide, rounded at apex, deep pink, pale proximally, the nerves whitish; stamens shorter than calyx, the filaments minutely ciliate; anthers 1 mm. long.

Type in the U. S. National Herbarium, no. 1,281,331, collected at Hacienda, Churú, Province of Paucartambo, Peru, altitude 3,500 meters, January, 1926, by F. L. Herrera (no. 1044).

This species evidently belongs to Section 16, *Rupicola*, of Knuth's monograph of Geraniaceae.⁷ The two Peruvian species of this relationship both have much more numerous, ebracteate, white flowers and non-mucronate leaf lobes.

The local name of the plant is given as *chile-chile*.

***Hypseocharis bilobata* Killip, sp. nov.**

Root cylindric, elongate, thickened, about 20 cm. long, 1.5 to 2 cm. thick, dark purplish; petioles 0.5 to 1 cm. long, puberulous; leaves 2 to 6 cm. long, pinnate, the rachis puberulous or glabrous, the leaflets alternate or subopposite, sessile or subsessile, glabrous, the lateral oblong-orbicular, 3 to 6 mm. long, 2 to 5 mm. wide, cordulate at base, the terminal ovate-orbicular, 6 to 10 mm. long, 5 to 8 mm. wide, cordulate and oblique at base, all shallowly bilobate at apex, the sinus to 1.5 mm. deep, the lobes erect, obtuse; peduncles 1.5 to 2 cm. long, 1-flowered, slender; sepals oblong, about 4 mm. long, 3 mm. wide, obtuse; corolla ?; ovary broadly ovoid.

Type in the U. S. National Herbarium, no. 1,190,039, collected near Cuzco, Peru, altitude 3,000 to 3,600 meters, by F. L. Herrera.

The shallowly bilobate leaflets distinguish this from the six other known species of the genus. *Hypseocharis tridentata* has a general resemblance to this species, but in that the leaflets are 3-toothed and the root is not strongly thickened.

***Saurauja micayensis* Killip, sp. nov.**

Tree, the branchlets stout, smooth, glabrous or very sparingly strigose, black; leaves oblong-obovate, about 30 cm. long, 15 cm. wide, short-acuminate at apex, subrotund at base, serrulate to base (serrulations about 8 mm. apart), petiolate (petioles 4 to 5 cm. long, stout, sparsely strigose), penninerved (lateral nerves 20 to 22 pairs, the nerves and veins conspicuous beneath), coriaceous, bright green, above glabrous, beneath strigose along the sides of the midrib (hairs very stiff, tuberculate-thickened at base), finely appressed-strigillose along sides of lateral nerves, and finely appressed-strigillose on

⁷ Pflansenreich IV. 129: 144. 1912.

veins, otherwise glabrous; inflorescence paniculate, about 24 cm. long, the rachis and branches stout, black, sparingly pulverulent; bracts lanceolate, 2 to 3 mm. long, acute; flowers 1 to 1.5 cm. wide, pinkish-white, many unisexual; sepals obovate, 2.5 to 3 mm. long, 2 to 2.5 mm. wide, rounded at apex, glabrous, minutely ciliolate at margin; petals oblong, 6 to 7 mm. long, 3.5 to 4.5 mm. wide, obtuse; stamens 15 to 20, 3 mm. long, the anthers linear-oblong, nearly 2 mm. long; styles 5, 3 mm. long; ovary glabrous.

Type in the U. S. National Herbarium, no 1,142,442, collected at La Galera, near the Micay Valley, Department of El Cauca, southwestern Colombia, altitude 1,900 to 2,000 meters, July 1, 1922, by E. P. Killip (no. 7932).

This species belongs to Buscalioni's section *Oligotrichae Scabrae*, and is probably most closely related to *S. pseudoparviflora* Busc., a plant with a less diffuse panicle and without the stiff hairs along the sides of the midrib of the leaves. These hairs are similar to those of *S. pratiniana*, a species of wholly different relationship.

The particular region in which this new species was collected is one of great botanical interest. On crossing the summit of the Western Cordillera at a point nearly due west of Popayán and descending toward the Pacific, the flora takes on a markedly different aspect. Most of the genera are the same as met with in other parts of the Republic, but the species are quite different from those of the northern part of the Pacific slope or of the Cauca and Magdalena valleys. Unfortunately my schedule permitted a stay of only a day and a half in this region, though about 350 numbers were collected. It is to be hoped that the area will be more thoroughly explored in the near future. Only a small portion of this collection has been studied, but several new species and at least two new genera have already been detected.

***Saurauja tambensis* Killip, sp. nov.**

Shrub, the tips of the branches setose-strigose, the hairs tuberculate at base; petioles very slender, 2 to 2.5 cm. long; leaves oblong-obovate, 20 to 25 cm. long, 7 to 9 cm. wide, acuminate at apex, cuncate at base, closely and sharply serrulate except at base, penninerved (lateral nerves 18 to 20 pairs), membranous, the midrib densely setose on both sides (hairs 2 to 3 mm. long, very slender, subappressed), the lateral nerves and the veins with fewer, shorter but similar hairs, the upper surface otherwise glabrous, the under surface with a few blotches of white tomentum; inflorescence about 20 cm. long (including the very slender peduncle 10 cm. long), densely white-tomentose and short-setose, few-branched, the branches about 3 cm. long, 3 or 4-flowered; flowers 1 cm. wide, white, some unisexual; sepals obovate-oblong, 4 to 5 mm. long, 4 mm. wide, rounded at apex, tomentose without, at length nearly glabrous, finely ciliolate, glabrous within; petals slightly longer than sepals, glabrous; stamens 15 to 20, 2 to 2.5 mm. long, the anthers oblong, barely 1 mm. long; styles 5, 1.5 mm. long; ovary glabrous.

Type in the U. S. National Herbarium, no. 1,196,269, collected between Portovelo (gold mine near Zaruma) and El Tambo, Province Oro, Ecuador, altitude 600 to 1,000 meters, September 2, 1923, by A. S. Hitchcock (no. 21281).

This species is nearest *S. intermedia* Busc., approaching the variety *granulosa* Busc., which has fewer (14 or 15) lateral leaf-nerves and shorter flowering branches, not clothed with the thick tomentum of *S. tambensis*.

***Saurauja rhamnifolia* Killip, sp. nov.**

Tree or shrub, the tips of the branches slender, finely and sparingly puberulent or glabrescent, with a very few short setae slightly swollen at base; petioles slender, 1.5 to 2 cm. long, glabrous or sparsely setulose; leaves obovate or oblong-obovate, 8 to 12 cm. long, 4 to 6 cm. wide, short-acuminate or acute at apex, cuneate at base, serrate or serrulate except in lower third (teeth mucronulate), penninerved (lateral nerves 14 or 15, arcuate-ascending from midrib to margin), dark green and glabrous or slightly pulvinate above, paler and glabrous beneath except for a few subappressed setae on the midrib and lateral nerves, membranous; inflorescence about 10 cm. long (including peduncle 3 cm. long), glabrous, the flowers few, subsessile on the main rachis or in two's or three's on short (about 1.5 cm.) branches; bracts linear, 4 to 5 mm. long, obtuse; sepals suborbicular, about 5 mm. long, minutely ciliate; petals oblong, 6 to 7 mm. long, 4 to 5 mm. wide, rounded at apex; stamens about 25, filaments 2 mm. long, the anthers linear, 3 mm. long; ovary glabrous; styles 5, slender, 4 to 5 mm. long, persistent; fruit depressed-globose, 1 cm. in diameter.

Type in the U. S. National Herbarium, no. 1,022,032, collected in the vicinity of Ambato, Ecuador, August 24-26, 1918, by J. N. Rose (no. 22377).

Saurauja rhamnifolia is related to the preceding species, differing in smaller, thicker leaves with the lateral nerves curved from their base, glabrous inflorescence, fewer and larger flowers, and much more numerous stamens, with linear, longer anthers.

***Valeriana herrerae* Killip, sp. nov.**

Plant herbaceous, 20 to 25 cm. high; root tuberous-thickened, about 1 cm wide, with numerous fibers; stem simple, slender, yellowish, densely pilose at nodes, glabrous or very sparingly pilosulous elsewhere; basal leaves entire, oblanceolate or spatulate, 1 to 1.5 cm. long, 0.6 to 0.8 cm. wide, obtuse, entire or undulate at margin, tapering to a slender petiole about 2.5 cm. long, dilated at base, glabrous or sparingly pilosulous; cauline leaves ovate or ovate-oblong, 0.8 to 1.2 cm. long, 0.4 to 0.5 cm. wide, obtuse at apex, acute at base, undulate-serrate, glabrous, pilosulous at lower part of margin, the petioles 0.8 to 1 cm. long, glabrous or pilosulous; inflorescence terminal and axillary, in densely flowered, trichotomous cymes in a narrow panicle, the terminal panicle about 3 cm. long; bracts linear-oblong, about 6 mm. long, 1.2 mm. wide, decreasing in size toward apex, obtusish; bracteoles linear, about 2 mm. long, 0.3 mm. wide, obtuse; corolla funnel-shaped, about 1 mm. long, 5-lobed, greenish white; anthers slightly exerted; fruit lance-oblong, about 2 mm. long, faintly 1-nerved on one face, nerveless on other, epappose.

Type in the U. S. National Herbarium, no. 1,281,330, collected at Hacienda Churd, Province of Paucartambo, Peru, altitude 3,600 meters, January, 1926, by F. L. Herrera (no. 1016).

This is a much more slender, less fleshy plant than *P. hyalimorhiza* Ruiz & Pav., its nearest relative. The cauline leaves are less deeply toothed; the cymes are more compact, and the flowers are much smaller and green, not purplish.

The local name is *atoc-atoc*.

SCIENTIFIC NOTES AND NEWS

Dr. S. C. BROOKS of the Hygienic Laboratory, U. S. Public Health Service, has resigned to become Professor of Physiology and Biochemistry and Head of the Department at Rutgers University.

Professor A. S. HITCHCOCK, of the Department of Agriculture is spending a month in Cuba studying the grasses of the island in cooperation with the Tropical Plant Research Foundation. He will return before Christmas.

The Pick and Hammer Club met at the Geological Survey on November 13. M. I. GOLDMAN described petrographic and structural features seen on excursions during and after the International Geological Congress at Madrid, and H. G. FERGUSON described the economic features. C. W. COOKE spoke on the stratigraphy of the beds bearing human remains in Florida.

The Petrologists' Club met at the home of H. G. FERGUSON on November 16. N. L. BOWEN gave some *Notes on Scottish igneous rocks*, and H. S. WASHINGTON discussed the *Petrology of St. Paul's Rocks, Atlantic Ocean*. J. W. GREIG, HERBERT INSLEY, and W. T. SCHALLER were elected members of the Steering Committee for 1927.

In recognition of the 80th birthday of Professor W. M. HOLMES, head curator of anthropology, U. S. National Museum, December 1, he was presented with a volume of personal letters from friends and colleagues in the United States and abroad. Professor Holmes came to the Smithsonian Institution as student artist in 1871.

Dr. DAVID FAIRCHILD, Foreign Seed and Plant Introduction, Bureau of Plant Industry, left New York December 9 on the steamship Conte Roosa for Gibraltar. The latter part of December he will leave Gibraltar for the west coast of Africa, where he will continue his collection and study of seeds and plants for the Bureau.

MESSRS. N. H. DARTON and A. C. SPENCER are on leave of absence from the Geological Survey and are doing private work in Venezuela and Panama, respectively.

MISS ANNA I. JONAS has been appointed assistant geologist on the Geological Survey.

B. C. RENICK has resigned from the Geological Survey and has gone into commercial geological work.

R. C. MOORE, State Geologist of Kansas, is temporarily at the Geological Survey doing research work on petroleum accumulation for the National Research Council. Professor ANDREW C. LAWSON, president of the Geological Society of America, who has just returned from a trip around the world, is also spending a few weeks in Washington.

Obituary

Dr. CHARLES VANCOUVER PIPER, a member of the ACADEMY, died February 11, 1926, in his 59th year. Dr. Piper was born in Victoria, B. C., and educated in the state of Washington and at Harvard. After ten years as professor of botany and zoology at the Washington Agricultural College he came to the Department of Agriculture. At first in the Office of the Agrostologist, he was, from 1905 until his death chief of the Office of Forage Crop Investigations. He was a born naturalist and from his student days an enthusiastic mountain climber and botanist, making extensive collections from the north-western states and from Alaska. He is the author of several works on the flora of Washington and Idaho, a large number of papers on systematic botany, and of a revision of *Festuca*, one of the larger genera of grasses. Of late years he was chiefly concerned with the introduction of superior forage grasses and with golf-turf problems. Dr. Piper had been in poor health for two years or more but he remained at work until, three days before the end, he had a paralytic stroke at his desk.

Dr. FRANK H. KNOWLTON, a member of the ACADEMY, died at his home in Ballston, Va., on November 22, at the age of sixty-six years. Dr. Knowlton was born in Vermont and educated at Middlebury. He came to the U. S. National Museum in 1884, and his work during the past forty years on Mesozoic and Cenozoic plants for the Geological Survey and the National Museum is well known. From 1907 until his death he was geologist and paleobotanist of the United States Geological Survey.

INDEX TO VOLUME 16

A † denotes the abstract of a paper before the Academy or an affiliated Society A § indicates an item published under the head Scientific Notes and News.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Anthropological Society of Washington Proceedings: 138, 374, 431
 Biological Society of Washington Proceedings 99, 309, 342, 428, 455.
 Entomological Society of Washington Proceedings: 103
 Geological Society of Washington. Proceedings: 63, 502.
 Philosophical Society of Washington Proceedings. 48, 98, 197, 259, 282, 330, 371
 Washington Academy of Sciences. Proceedings: 276.

AUTHOR INDEX

- ADAMS, LEASON H. Chemistry as a branch of mathematics 266.
 ALDEN, WILLIAM C †Glaciation and physiography of Wind River Mts, Wyo 73
 ALLEN, E T †Nature of hot springs. 74
 ALLISON, SAMUEL K. L_{II} L_{III} levels of atoms Si, P, S, Cl, note on 7.
 AUSTIN, L. W. Constants of the Austin-Cohen transmission formula, proposed changes in. 228.
 — Direction determinations of atmospheric disturbances on Isthmus of Panama. 487.
 — Long distance radio receiving measurements and atmospheric disturbances at Bureau of Standards in 1925. 398.
 — Present status of radio atmospheric disturbances. 41.
 BAILEY, VERNON. †Beaver farming, progress in. 99.
 — Mammals of the vicinity of Washington. 441.
 BAKER, A. C. Entomological taxonomy: economic viewpoint. 58
 BALDWIN, S. PRENTISS. †Intensive study of life history of birds 456.
 — †Life history of house wren. 456.
 BALL, E. D. Entomological taxonomy: educational standpoint. 64.
 BARAFF, CHARLES. Transformations associated with the Lorents group. 81.
 BARAFF, CHARLES Transformations associated with the Lorents group and their invariants 377.
 BARTSCH, PAUL. †Birds of the Dry Tortugas. 343.
 BABSLER, R S †Stratigraphic use of conodonts. 72
 BAUER, LOUIS A. †Sunspots and earth's magnetic storms. 282
 BERGER, ALWIN *Rubus*, new South American species of. 160.
 BLACKWELDER, ELIOT. Photography for the field geologist 93.
 BLAKE, S. F. *Disterygma*, new species of. 361.
 — *Melampodrinus*, new American 418
 — *Verbesininar*, new South American. 215.
 BORN, MAX. †New methods in the Quantum theory 339
 BÖVING, A. G †Entomological collections in museums of Denmark and Sweden. 106.
 BOWEN, N L. Petrographic and X-ray study of thermal dissociation of dumortierite. 176.
 BOWIE, WILLIAM. Deflection of the vertical in Porto Rico. 29.
 — Earthquakes from isostatic viewpoint 245.
 BRADLEY, W. H. †Green River formation, interpretations of. 74.

- BRANDT, HERBERT W. †Birds in Alaska. 311.
- BREIT, G. Diffraction by a grating. 201.
- Radio evidence of existence of Kennelly-Heavyside layer. 98.
- BRYAN, KIRK. †Recent deposits in Chaco, N Mex., in relation to prehistoric peoples of Pueblo Bonito. 75.
- BUSHNELL, DAVID I., JR. Ancient soapstone quarry in Albermarle Co., Va. 525
- CHAMBLISS, C. E. †Wild rice [*Zizania*], food plant of birds and man. 310
- CHASE, AGNES. †Brasil, hunting grasses in. 99
- COBLENTZ, W. W. †Sumatra eclipse expedition 372
- COCHRAN, DORIS M. Pelobatid batrachian from Borneo, new 446
- COOK, O. F. Cotton, new species from Colombia and Ecuador. 545
- Cotton, new species from Sonora and Sinaloa, Mex. 333.
- Palms, new genus (*Denea*) based on *Kentia forsteriana*. 392.
- COOKE, WYTHE. Eocene mollusks, new, from Jackson, Miss. 132
- COOPER, JOHN M. †Têtes de Boule of the Upper St. Maurice 138
- CUSHMAN, R. A. †Parasites of pine tip moth. 104
- DARTON, N. H. Guantánamo basin, Cuba, geology of. 324
- DAY, ARTHUR L. Earthquake movements, difficulties in study of local. 250
- DELLINGER, J. H. Application of radio transmission phenomena to problems of atmospheric electricity. 162.
- DORSEY, N. ERNEST. Lightning stroke, a. 87.
- †Thunderbolt and its results, a. 49
- DRYDEN, H. L. †Measurement of performance of desk fans. 372.
- ELDRID, BYRON E. †Physical observations on hearing and deafness. 258
- FERGUSON, S. P. †Meteorology of total solar eclipse of Jan. 24, 1925 46.
- FLEMING, J. A. Magnetic and electric survey of the earth, physical and cosmical bearings and development. 109.
- GARDNER, JULIA. *Ostrea multilirata*, restoration of. 513.
- GAULT, ROBERT H. †Touch as substitute for hearing in interpretation and control of speech. 50.
- GIDLEY, J. W. †Fossil man associated with mammoth in Florida. 310.
- GILMORE, C. W. †Fossil tracks from the Grand Canyon. 314.
- GOLDMAN, E. A. †Overbrowsing by Kaibab deer. 101.
- GREELEY, W. B. †Proposed changes in boundary of Yellowstone National Park in relation to wild life. 102.
- GROSS, A. O. †Heath hen on Marthas Vineyard, threatened extinction of. 430.
- †Jungle life of Panama. 430.
- HANN, RAYMOND M. Condensation of aldehydes with diphenyl isothiohydantoin. 169.
- Thiasolidone, 2-thio-3-(2-p-xylyldyl)-4-keto, and some of its derivatives. 31.
- HAY, OLIVER P. Elephant, remains of, found at Port Williams, Wash. 143.
- Mastodons, two new Pleistocene. 35.
- Pleistocene vertebrates found in Florida, geologic age of. 347.
- Tuolumne Table Mt., geologic age of. 358
- HECK, N. H. Seismology, outstanding problems in. 240.
- HEINRICH, C. †Distribution of European pine-shoot moth. 104.
- HENDERSON, W. C. †Elk, Jackson Hole herd. 102.
- HESS, FRANK L. †Oolites. 76.
- HEYL, PAUL R. †Perpetual motion in the 20th century 52.
- HITCHCOCK, A. S. †Distribution and relationship of Alaska grasses. 311.
- HOUGH, WALTER. †Pueblo archeology, 50 years of. 431.
- HOWARD, L. O. †Mosquito, salt marsh, problem. 100.
- †Third International Congress of Entomologists at Zurich. 105.
- HRDLÍČKA, ALES. †Ancient man in the far east. 139.
- HUBBARD, J. W. Cotton, new species from Colombia and Ecuador. 545.

- HENSHAW, J. W. Cotton, new species from Sonora and Sinaloa, Mex. 333
 HILSBURT, E. O. †Propagation of radio waves over the earth. 198.
 — †Spectrum of hydrogen in the stars and in the laboratory. 373.
 HUMPHREYS, W. L. †Mammato-cumulus, unusual display of. 51.
 JACKSON, W. H. †Pawnee Indians of 50 years ago. 139.
 — †Pueblo villages and cliff ruins 374.
 JUDSON, L. V. †Geodetic instruments from viewpoint of physicist. 51.
 KALMBACH, E. R. †Blackbirds vs. rice in Louisiana. 313
 KANOLT, C. W. †Cryogenic Laboratory, Bureau of Mines, work of. 282
 — †Helium work at Cryogenic Laboratory, Bureau of Mines. 282
 KEARNEY, T. H. †Pollination in cotton. 103.
 KEENAN, GEORGE L. Optical properties of some sugars 433
 KEYES, MARY S. Rocks of eastern China. 291.
 KILLIP, ELLSWORTH P. South America, new plants from western. 565
 — †*Tetrastylis* (*Passifloraceae*), new species of. 365.
 — †*Valeriana*, section *Porteria*, Venezuelan species of. 422.
 LAPORTE, OTTO. †Recent developments in theory of periodic systems of the elements 341
 — Ruthenium, arc spectrum regularities for. 143.
 LEONARD, EMORY C. *Sanchezia* (*Acanthaceae*), new species of. 484.
 LONGLEY, A. E. Triploid citrus. 543
 LOTKA, ALFRED J. Frequency distribution of scientific productivity. 317.
 — Progressive adjustment of age distribution to fecundity. 505.
 MACLEOD, W. C. Piscataway royalty: stone age government and inheritance rulings. 301
 MANN, WILLIAM M. Myrmecophiles, new neotropical. 448.
 MANSFIELD, WENDELL C. Choptank formation in the Nomine Cliffs, Va 175.
 MARKLEY, KLAIRE S. Condensation of aldehydes with diphenyl isothiohydantoin 169.
 MARSART, JEAN †*Araucaria excelsa*, internal sensations of 278
 MCGGERS, W F Ruthenium, arc spectrum regularities for 143
 MEINER, OSCAR EDWARD Plants as indicators of ground water 553.
 MERRIAM, C HART. Shasta, source of name 522
 MERTIE, J B., JR †Paleozoic geology of interior Alaska 78
 MICHELSON, TRUMAN. Algonquian languages, principles of. 369
 MINER, JOHN RICE Simple formula for welding curves in graduating observational data 141
 MISER, HUGH, D †Erosion in San Juan Canyon, Utah 68
 MOON, C. †Method of comparing relative frequencies of a tuning fork and a pendulum 48
 MURIE, O. J †Alaskan big brown bear. 309
 NUTTING, P G. Pressures in planetary atmospheres 254
 OBERHOLSER, HARRY C. †Bird reservations of Louisiana 102.
 — †Birds of Farallon Islands. 102.
 — †Passerine birds, new East Indian. 515
 — †Upper Mississippi wild life and fish refuge 100
 ORLEMAN, M B †Confused nomenclature of man and higher apes. 312.
 PALMER, T. S †American Ornithologists Union, report of meeting in New York, Nov. 1925. 101
 — †Branhan cardinal in Washington. 342
 PEARL, RAYMOND. Time recorder for quantitative work in animal behavior. 541.
 PETERS, W. J. †Earth currents, 27 day interval in. 373.
 PHILLIPS, JOHN C. †Introducing foreign and American birds into new localities. 343.
 PITTIER, H. *Gynerthera* and *Bombacopsis*, with key to American genera of *Bombacaceae*. 207.

- PITTMER, H. *Valeriana*, section *Porteria*, Venezuelan species of. 422.
- PROROK DE, BYRON KHUN. †Carthage, excavations of 1924 and dead cities of Sahara. 290
- PUTNAM, GEORGE R. Equilibrium theory of the earth's crust. 285.
- RICHARDSON, C. H. Insect physiology. 103.
- ROHWEB, S. A. Entomological taxonomy, its aims and failures. 53.
- †*Tiphia punctata* collected in Dominican Republic. 107.
- SCHALLER, W. T. †Lithium pegmatites, genesis of. 76.
- SCHMIDT, WALDO. †Invertebrates, collecting, in South America. 314.
- SERVICE, J. H. †Radio-acoustic ranging, recent results with. 198.
- SHANNON, RAYMOND C. †"Insect," use of term. 106.
- *Phlebotomus*, occurrence of in Panama. 190.
- SMITH, PHILIP S. †Alaskan studies, fields for future. 79.
- SNYDER, THOMAS E. Termites, new, from Guatemala, Costa Rica, and Colombia. 18.
- †Termites, oviposition in. 105.
- SOLER, EMMANUELE. Gravity work at the second meeting of the International Geodetic and Geophysical Union. 261.
- STANDLEY, PAUL C. *Calatola*, new species of. 413.
- Chiapas, new plants from, collected by Purpus. 14.
- *Ilex*, Costa Rican species of. 481.
- STEARNS, HAROLD T. †Kilauea Volcano, explosions in 1924. 502.
- STEINNEGER, LEONARD. Toad, new, from China. 445.
- STEPHENSON, L. W. Geology of Atlantic and Gulf Coastal Plain. 400.
- STILES, C. W. †Confused nomenclature of man and higher apes. 312.
- SVEDDRUP, H. U. Tides on the north Siberian shelf. 529.
- SWANTON, JOHN R. Mental assimilation of races. 493.
- Subjective element in magic. 109.
- TONDORF, F. A. Earthquakes: retrospect. 233.
- TRELHASE, WILLIAM. *Piperaceae*, new, from South America and Mexico. 204.
- TUCKERMAN, L. B. †Mental completion of patterns suggested by geometrical arrangement. 48.
- TUVE, M. A. †Radio evidence of existence of Kennelly-Heavyside layer. 98.
- VAN OSTRAND, C. E. †Deep earth temperatures and geological structure. 503.
- VAUGHAN, THOMAS WAYLAND. Igneous rocks of northeastern West Indies and geology of island of Anguilla. 345.
- VEDDER, E. B. †Lead tetraethyl, toxicity of. 279.
- WALCOTT, C. D. †Robeson Peak section 72.
- WALKER, ERNEST P. †Wild life of Alaska and its protection. 429.
- WASHINGTON, HENRY S. Granites of Central Spain. 409.
- Rocks of eastern China. 291.
- Santorini eruption in 1925. 1.
- WHERRY, EDGAR T. Prickly-pear, new circumneutral soil species, from Middle Atlantic states. 11.
- †Wild flowers, exploring for, in Gulf States. 429.
- WHITE, DAVID. †Geologic factors affecting Pleistocene ice sheet development in North America. 69.
- WHITMAN, V. E. †Electrification of dust clouds, studies in. 98.
- WOODRING, W. P. †Miocene climate of tropical America. 77.
- WYCKOFF, R. W. G. Petrographic and X-ray study of thermal dissociation of dumortierite. 178.
- YERKES, R. M. †Psychology as social biology. 276.

SUBJECT INDEX

- Archaeology.** Ancient soapstone quarry in Albemarle Co., Va. D. I. BUSHNELL, JR. 525.
- Carthage excavations of 1924 and dead cities of Sahara. B. K. DE PROROK. 280.
- †Pueblo archeology, 50 years of W. HUGH. 431.
- See also *Anthropology*.
- Anthropology.** Algonquian languages, principles of. T. MICHELSON. 369.
- †Ancient man in the far east. A. HRDLÍČKA. 139.
- Mental assimilation of races. J. R. SWANTON. 493.
- †Pawnee Indians of 50 years ago. W. H. JACKSON. 139.
- †Pueblo archeology of 50 years ago. W. HUGH. 431.
- †Pueblo Bonito, life of prehistoric peoples of, recent deposits in Chaco, N. Mex., in relation to. K. BRYAN. 75.
- †Pueblo villages and cliff ruins. W. H. JACKSON. 374.
- Subjective element in magic. J. R. SWANTON. 193.
- †Têtes de Boule of the upper St. Maurice. J. M. COOPER. 138.
- See also *Archaeology*, *Ethnology*.
- Astronomy.** †Solar eclipse, total, of Jan. 24, 1925, meteorology of. S. P. FERGUSON. 46.
- †Sumatra eclipse expedition. W. W. COBLENTS. 372.
- Atomic Physics.** L_{II} L_{III} levels of the atoms Si, P, S, Cl. S. K. ALLISON. 7.
- Biology.** †Alaska, wild life of, and its protection. E. P. WALKER. 429.
- Animal behavior, time recorder for quantitative work in. R. PEARL. 541.
- †Psychology as social biology. R. M. YERKES. 276.
- See also *Botany*, *Zoology*.
- Botany.** †*Araucaria excelsa*, internal sensations of. J. MASSART. 278.
- Bombacaceae*, key to American genera of. H. PITTIER. 207.
- Calatola*, new species of. P. C. STANDLEY. 413.
- Chiapas, new plants from, collected by Purpus P. C. STANDLEY. 14.
- Cotton, new species from Colombia and Ecuador. O. F. COOK and J. W. HUBBARD. 545.
- Cotton, new species from Sonora and Sinaloa. O. F. COOK and J. W. HUBBARD. 333.
- Disterigma*, new species of. S. F. BLAKE. 361.
- †Grasses in Brazil, hunting. A. CHASE. 99.
- †Grasses of Alaska, distribution and relationship of. A. S. HIRCHCOCK. 311.
- Gynanthera* and *Bombacopsis*, with key to American genera of *Bombacaceae*. H. PITTIER. 207.
- Ilex*, Costa Rican species of. P. C. STANDLEY. 481.
- Indicators of ground water, plants as. O. E. MEINER. 553.
- Melampodiinae*, new American. S. F. BLAKE. 418.
- Palms, new genus (*Denea*) based on *Kentia forsteriana*. O. F. COOK. 392.
- Piperaceae*, new from South America and Mexico. W. TRELEASE. 204.
- †Pollination in cotton. T. H. KEARNEY. 103.
- Prickly-pear, new circumneutral soil species from Middle Atlantic States. E. T. WHERRY. 11.
- Rubus*, new South American species of. A. BERGER. 160.
- Sanchezia* (*Acanthaceae*), new species of. E. C. LEONARD. 484.
- South America, new plants from western. E. P. KILLIP. 565.
- Tetrastylis* (*Passifloraceae*), new species of. E. P. KILLIP. 365.
- Valeriana*, section *Porteria*, Venezuelan species of. H. PITTIER and E. P. KILLIP. 422.
- Verbesininae*, new South American. S. F. BLAKE. 215.
- †Wild flowers, exploring for, in Gulf States. E. T. WHERRY. 429.
- †Wild rice [*Zizania*], food plants of birds and man. C. E. CHAMBLISS. 310.

Botany (Continued)

See also *Biology*, *Genetics*.

Chemistry. Aldehydes, condensation of, with diphenyl isothiohydantoin. R. M. HANN and K. S. MARKLEY. 169.

†Cryogenic Laboratory, Bureau of Mines, work of. C. W. KANOLT. 282.

†Helium, work on, at Bureau of Mines. C. W. KANOLT. 282.

†Lead tetraethyl, toxicity of. E. B. VEDDER. 279.

Mathematics, chemistry as a branch of. L. H. ADAMS. 266

Thiasolidone, 2-thio-3-(2-p-xylydyl)-4-keto, and some of its derivatives. R. M. HANN. 31.

Crystallography Optical properties of some sugars. G. L. KERNAN. 433.

Ethnography. Shasta, source of name. C. H. MERRIAM. 522.

Ethnology. Algonquian languages, principles of. T. MICHELSON. 369

Mental assimilation of races. J. R. SWANTON. 493.

Piscataway royalty: stone age government and inheritance rulings. W. C. MACLEOD. 301.

Subjective element in magic. J. R. SWANTON. 193.

See also *Archeology*, *Anthropology*.

Entomology. †Collections, entomological, in museums of Denmark and Sweden. A. G. BÖVING. 106.

†"Insect," use of term. R. C. SHANNON. 106.

†International Congress of Entomologists at Zurich, Third. L. O. HOWARD. 105.

†Mosquito, salt marsh, problem. L. O. HOWARD. 100.

†Moth, European pine-shoot, distribution of. C. HEINRICH. 104.

Myrmecophiles, new neotropical. W. M. MANN. 448.

†Parasites of pine-tip moth. R. A. CUSHMAN. 104.

Phlebotomus, occurrence of, in Panama. R. C. SHANNON. 190.

Physiology, insect. C. H. RICHARDSON. 103.

†Taxonomy, entomological: aims and failures. S. A. ROHWER, 53; economic

viewpoint, A. C. BAKER, 56; educational viewpoint, E. D. BALL. 64.

Termites, new, from Guatemala, Costa Rica, and Colombia. T. E. SNYDER. 18.

†Termites, oviposition in. T. E. SNYDER. 105.

†*Typha punctata* collected in Dominican Republic. S. A. ROHWER. 107.

General Science. †Sumatra eclipse expedition. W. W. COBLENS. 372.

Genetics. Triploid citrus. A. E. LONGLEY. 543.

Geodesy. Deflection of the vertical in Porto Rico. W. BOWIE. 29.

Equilibrium theory of earth's crust. G. R. PUTNAM. 285.

Gravity work at the second meeting of the International Geodetic and Geophysical Union. E. SOLER. 261.

†Instruments, geodetic, from viewpoint of physicist. L. V. JUDSON. 51.

Geology. †Alaskan studies, fields for future. P. S. SMITH. 79.

Anguilla, Island of, geology of. T. W. VAUGHAN. 345.

Choptank formation in the Nomini Cliffs, Va. W. C. MANSFIELD. 175.

Coastal Plain, Atlantic and Gulf, geology of. L. W. STEPHENSON. 460.

†Erosion in San Juan Canyon, Utah. H. D. MISER. 68.

†Glaciation and physiography of Wind River Mts., Wyo. W. C. ALDEN. 73.

†Green River formation, interpretations of. W. H. BRADLEY. 74.

Guantánamo Basin, Cuba, geology of. N. H. DARTON. 324.

†Hot springs, nature of. E. T. ALLEN. 74.

§International Geological Congress at Madrid, May 24-31, 1926. 80, 199, 260, 264.

†Kilauea Volcano, explosions in 1924. H. T. STEARNS. 502.

†Lithium pegmatite, genesis of. W. T. SHALLER. 76.

†Miocene climate of tropical America. W. P. WOODRING. 77.

†Oolites. F. L. HESS. 76.

Ostrea multilirata, restoration of. J. GARDNER. 513.

Geology (Continued)

- Paleozoic geology of interior Alaska. J. B. MARTIN, JR. 78.
 Photography for the field geologist. E. BLACKWELDER. 93.
 †Pleistocene ice sheet development in North America, geologic factors affecting. D. WHITE. 69.
 Pleistocene vertebrates found at Vero and Melbourne, Fla., geologic age of. O. P. HAY. 387.
 †Recent deposits in Chaco, N. Mex., in relation to life of prehistoric peoples of Pueblo Bonito. K. BRYAN. 75.
 †Robson Peak section. C. D. WALCOTT. 72.
 †Stratigraphic use of conodonts. R. S. BASSLER. 72.
 †Temperatures, deep earth, and geologic structure. C. E. VAN OSTRAND. 503.
 Tuolumne Table Mt., geological age of. O. P. HAY. 388.
 West Indies, igneous rocks of northeastern. T. W. VAUGHAN. 345.
 See also *Geophysics, Mineralogy, Petrology, Vulcanology*.
Geophysics. †American Geophysical Union, officers for 1926-1929. 375.
 Gravity work at the second meeting of the International Geodetic and Geophysical Union. E. SOLER. 261.
 Pressures in planetary atmospheres. P. G. NUTTING. 254.
 Tides on the north Siberian shelf. H. U. SVENDRUP. 529.
 See also *Geology, Physics, Terrestrial Magnetism, Vulcanology*.
Hydrology. Ground water, plants as indicators of. O. E. MEINER. 553.
Mammalogy. †Alaska, wild life of, and its protection. E. P. WALKER. 429.
 †Man and higher apes, confused nomenclature of. C. W. STILES and M. B. ORLEMAN. 312.
 Washington, mammals of vicinity of. V. BAILEY. 441.
 See also *Zoology*.
Mathematics. Chemistry as a branch of mathematics. L. H. ADAMS. 266.
 Curves, simple formula for welding, in graduating observational data. J. R. MINER. 141.

- Transformations associated with the Lorents group. C. BARAFF. 81.
 Transformations associated with the Lorents group and their invariants. C. BARAFF. 377.
Meteorology. Lightning stroke, a. N. E. DORSEY. 87.
 †Mammato-cumulus, unusual display of. W. L. HUMPHREYS. 51.
 †Solar eclipse, total, of Jan. 24, 1925, meteorology of. S. P. FERGUSON. 46.
 †Thunderbolt and its results, a. N. E. DORSEY. 49.
Mineralogy. Petrographic and X-ray study of thermal dissociation of dumortierite. N. L. BOWEN and R. W. G. WYCKOFF. 178.
Necrology. †HUNTER, W. D. 106.
 †KLAPHAAR, PETER. 108. KNOWLTON, F. H. 573. †LEE, WILLIS T. 375. PIPER, CHARLES V. 574. †RANSOM, BRAYTON HOWARD. 105. SARGFORD, WILLIAM E. 80.
Optics. †Mental completion of patterns suggested by geometrical arrangement. L. B. TUCKERMAN. 48.
Ornithology. †Alaska, observations on birds in. H. W. BRANDT. 311.
 †Alaska, wild life of, and its protection. E. P. WALKER. 429.
 †American Ornithologists Union, report of meeting in New York, Nov. 1925. T. S. PALMER. 101.
 †Blackbirds vs. rice in Louisiana. E. R. KALMBACH. 313.
 †Brazilian cardinal in Washington. T. S. PALMER. 342.
 †Dry Tortugas, birds of. P. BARTCH. 343.
 †Farallon Islands, birds of. H. C. OBERHOLSER. 102.
 †Heath hen on Marthas Vineyard, threatened extinction of. A. O. GROSS. 430.
 †International Ornithological Congress at Copenhagen. T. S. PALMER. 311.
 †Introducing foreign and American birds into new localities. J. C. PHILLIPS. 343.
 †Life history of birds, intensive study of. S. P. BALDWIN. 456.
 †Life history of house wren. S. P. BALDWIN. 456.

Ornithology (Continued)

- †Panama, jungle life of. A. O. GROSS. 430.
Passerine birds, new, of East Indies. H. C. OBERHOLSER. 515.
 †Reservations, bird, of Louisiana. H. C. OBERHOLSER. 102.
 †Upper Mississippi River wild life and fish refuge. H. C. OBERHOLSER. 100.

See also *Zoology*.

Paleontology. Elephant, remains of, found at Port Williams, Wash. O. P. HAY. 143.

Eocene mollusks, new from Jackson, Miss. W. COOKE. 132.

†Fossil man associated with mammoth in Florida. J. W. GIDLEY. 310.

†Fossil tracks from the Grand Canyon. C. W. GILMORE. 314

Mastodons, two new Pleistocene. O. P. HAY. 35.

Petrology. Granites of central Spain. H. S. WASHINGTON. 409.

Igneous rocks of northeastern West Indies. T. W. VAUGHAN. 345.

Rocks of eastern China. H. S. WASHINGTON and M. G. KEYS. 291.

See also *Geology*.

Photography. Geologist, photography for the field. E. BLACKWELDER. 93.

Physics. †Cryogenic Laboratory of Bureau of Mines, work of. C. W. KANOLT. 282.

Diffraction by a grating. G. BREIT. 201.

†Earth currents, 27 day intervals in. W. J. PETERS. 373.

†Electrification of dust clouds, studies in. V. E. WHITMAN. 98.

†Hearing and deafness, physical observations on. B. E. ELDRID. 258.

†Helium, work on, at Cryogenic Laboratory, Bureau of Mines. C. W. KANOLT. 282.

†Instruments, geodetic, from viewpoint of physicist. L. V. JUDSON. 51.

L_{21} L_{23} levels of atoms Si, P, S, Cl, note on. S. K. ALLISON. 7.

†Measurement of performance of desk fans. H. L. DRYDEN. 372.

†Periodic systems of the elements, recent developments in theory of. O. LAPORTE. 341.

†Perpetual motion in the twentieth century. P. R. HAYL. 82.

†Propagation of radio waves over the earth. E. O. HULBURT. 196.

†Quantum theory, new methods in the. M. BORN. 339.

†Radio-acoustic ranging, recent results with. J. H. SERVICE. 198.

†Radio evidence of existence of Kennelly-Heavyside layer. G. BREIT and M. A. TUVE. 98

†Relative frequencies of a tuning fork and a pendulum, method of comparing. C. MOON. 48.

†Spectrum of hydrogen in the stars and in the laboratory. E. O. HULBURT. 373.

†Sunspots and earth's magnetic storms. L. A. BAUER. 282

†Thunderbolt and its results, a. N. E. DORSET. 49.

†Touch as substitute for hearing in interpretation and control of speech. R. H. GAULT. 50.

See also *Geophysics*, *Meteorology*, *Optics*, *Spectroscopy*.

Population Statistics. Progressive adjustment of age to fecundity. A. J. LOTKA. 506.

Radiotelegraphy. Atmospheric disturbances at the Bureau of Standards in 1925, long distance radio receiving measurements and. L. W. AUSTIN. 398.

Atmospheric disturbances on Isthmus of Panama, direction determinations of. L. W. AUSTIN. 487.

Atmospheric disturbances, radio, present status of. L. W. AUSTIN. 41.

Atmospheric electricity, application of radio transmission phenomena to problems of. J. H. DELLINGER. 162.

Austin-Cohen transmission formula, proposed changes in constants of. L. W. AUSTIN. 228.

†Kennelly-Heavyside layer, radio evidence of existence of. G. BREIT and M. A. TUVE. 98.

Propagation of radio waves over the earth. E. O. HULBURT. 196.

†Radio-acoustic ranging, recent results with. J. H. SERVICE. 198.

Radiology (Continued)

Scientific Notes and News. 28, 52, 79, 107, 146, 168, 199, 231, 259, 283, 315, 344, 375, 422, 504, 573.

Seismology. Earthquakes: retrospect, F. A. TONDORF, 233; outstanding problems in seismology, N. H. HECX, 240; iso-static viewpoint, W. BOWEN, 245; difficulties in study of local earth movements, A. L. DAY. 250

Statistics. Frequency distribution of scientific productivity. A. J. LOTKA. 317.

Progressive adjustment of age distribution to fecundity. A. J. LOTKA. 505.

Spectroscopy. †Hydrogen, spectrum of, in the stars and in the laboratory. E. O. HULBURT. 373.

Ruthenium, arc spectrum regularities for. W. F. MEGGERS and O. LAPORTE. 143.

Terrestrial Magnetism †Earth currents, 27 day interval in. W. J. PETERS. 373.

Magnetic and electric survey of the earth, physical and cosmical bearings and development J. A. FLEMING 109.

†Sunspots and earth's magnetic storms. L. A. BAUER. 282.

Volcanology. †Kilauea Volcano explosions in 1924. H. T. STEARNS 502.

Santorini eruption in 1925. H. S. WASHINGTON. 1.

Zoology. †Bear, big brown, in Alaska O. J. MURIE. 309.

†Beaver farming, two years' progress in. V. BAILEY. 99

†Elk, Jackson Hole herd. W. C. HENDERSON. 102.

†Invertebrates, collecting, in South America. W. SCHMIDT. 314

†Kaibab deer, overbrowsing by E. A. GOLDMAN. 101.

Mammals of vicinity of Washington. V. BAILEY. 441.

Pelobatid batrachian from Borneo, new. D. M. COCHRAN. 446.

Toad, new, from China. L. STEJNEGER. 445.

†Yellowstone National Park, proposed changes in boundary of, in relation to wild life. W. B. GREELEY. 102.

See also *Biology*, *Entomology*, *Mammalogy*, *Ornithology*.

